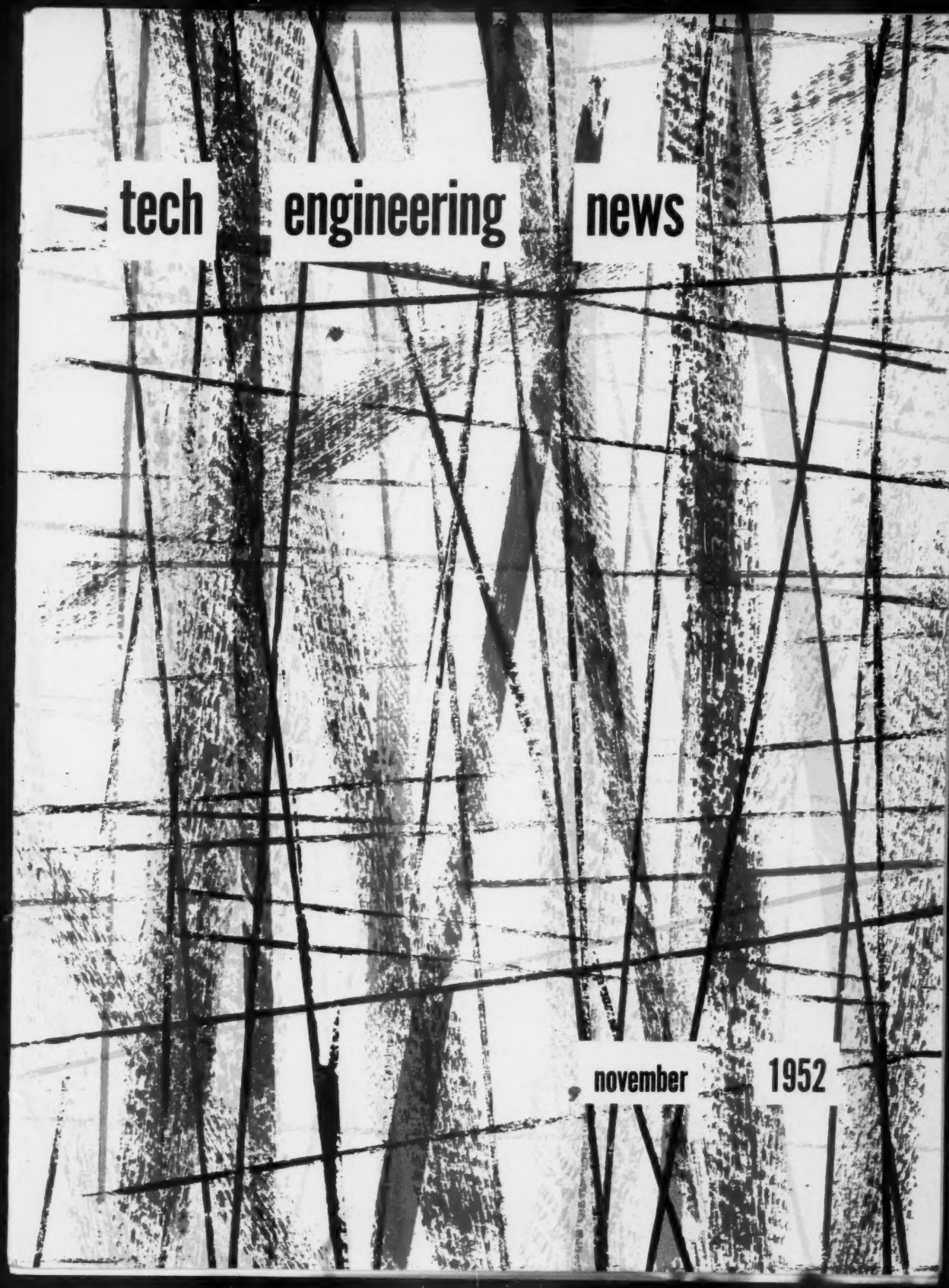

tech engineering news
november 1952

To keep steel strip on the straight and narrow → → → →

. . . at 1000 feet per minute!

● Threading its way through a gigantic continuous-annealing furnace at speeds up to 1000 feet per minute, steel strip behaves erratically. It tends to wander and weave. It fouls the rolls. Sometimes it breaks. Then production on a multi-million-dollar unit, designed for high-speed operation, slows down or stops dead . . . a very costly business.

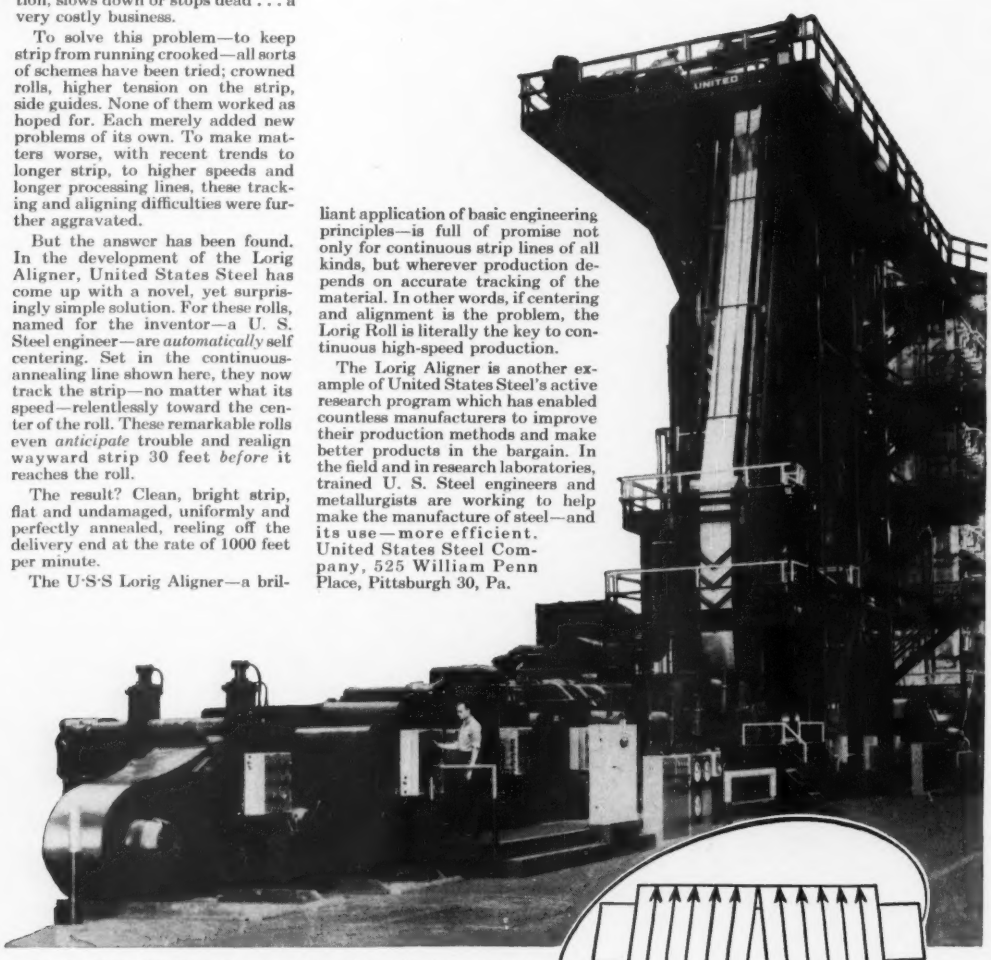
To solve this problem—to keep strip from running crooked—all sorts of schemes have been tried; crowned rolls, higher tension on the strip, side guides. None of them worked as hoped for. Each merely added new problems of its own. To make matters worse, with recent trends to longer strip, to higher speeds and longer processing lines, these tracking and aligning difficulties were further aggravated.

But the answer has been found. In the development of the Lorig Aligner, United States Steel has come up with a novel, yet surprisingly simple solution. For these rolls, named for the inventor—a U. S. Steel engineer—are *automatically* self centering. Set in the continuous-annealing line shown here, they now track the strip—no matter what its speed—relentlessly toward the center of the roll. These remarkable rolls even *anticipate* trouble and realign wayward strip 30 feet *before* it reaches the roll.

The result? Clean, bright strip, flat and undamaged, uniformly and perfectly annealed, reeling off the delivery end at the rate of 1000 feet per minute.

The U·S·S Lorig Aligner—a brilliant application of basic engineering principles—is full of promise not only for continuous strip lines of all kinds, but wherever production depends on accurate tracking of the material. In other words, if centering and alignment is the problem, the Lorig Roll is literally the key to continuous high-speed production.

The Lorig Aligner is another example of United States Steel's active research program which has enabled countless manufacturers to improve their production methods and make better products in the bargain. In the field and in research laboratories, trained U. S. Steel engineers and metallurgists are working to help make the manufacture of steel—and its use—more efficient. United States Steel Company, 525 William Penn Place, Pittsburgh 30, Pa.



THE U·S·S LORIG ALIGNER consists of a divided roll (conical effect exaggerated at the right) with each conical half running on a common rotating axle that is slightly deflected in the center so that the upper surfaces of the cones form a straight surface. As the strip passes over the roll, strongly converging lateral forces are set up to exert a powerful centering action on the strip that immediately corrects any deviation and keeps the strip running straight and true.

USS

UNITED STATES STEEL

Ever Wonder Why a Wave Rolls?

MAYBE it's a long step from the rolling ocean waves to an Aircraft Corporation — and maybe *not*.

Here at Goodyear Aircraft, the step is a short one. For we do many things besides build aircraft and other defense items. Typical of the many outstandingly different fields into which our engineers are free to "dig" is the recent study of ocean waves and their effects, completed for a group of offshore oil-drilling companies. Or the study of fish and how they swim—of importance, finally, to submarine and ship designers.

All this because Goodyear Aircraft Corporation is more than a major supplier of armament components—more than just a specialized organization in the aircraft field. Today, Goodyear Engineers are working with plastics, metals, wood—in fields ranging far from the aeronautical activities implied in the GAC name.

As a result, Goodyear Aircraft Corporation offers every engineer an opportunity to specialize in the field of his own choice—on projects with normal times applications as well as the current defense projects. As a part of the world-wide Goodyear organization, Goodyear Aircraft is a division of the world's largest rubber company — a world-known engineering organization that is *production-minded*.

There's a place for YOU in the Goodyear Aircraft picture—whatever your field may be. So check over the list of opportunities in the panel—see for yourself the many unique opportunities for progress and advancement—*with an assured future*—at Goodyear Aircraft.

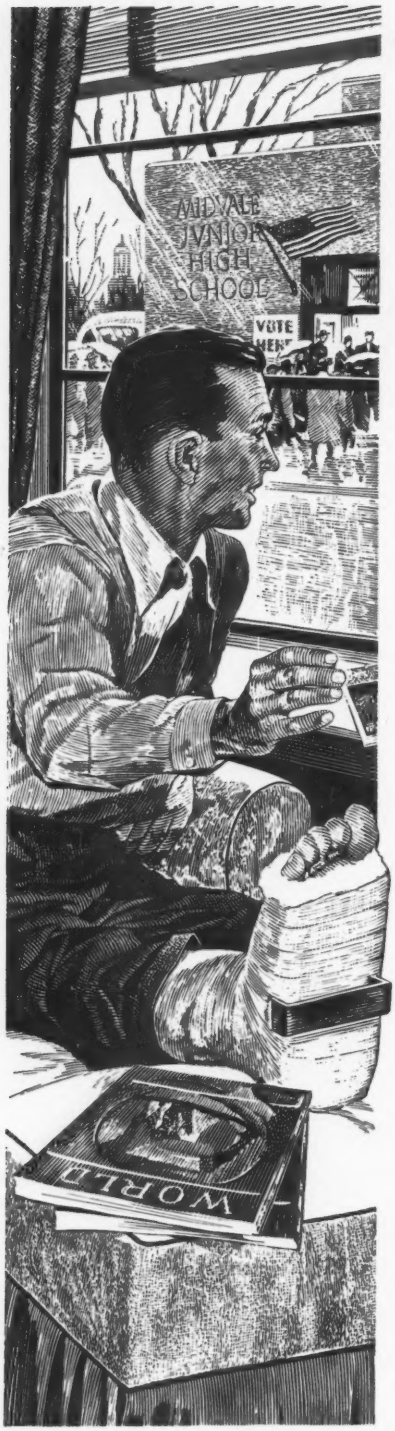
GOODYEAR AIRCRAFT

ENGINEERS WANTED *to investigate the opportunities in research, design, development and production of:*

AIRPLANES, AIRSHIPS, HELICOPTERS, GUIDED MISSILES, ELECTRONIC COMPUTERS, AIRCRAFT COMPONENTS, GUIDANCE SYSTEMS, RADOMES, TRANSPARENT ENCLOSURES, REINFORCED PLASTICS, BONDED SANDWICH STRUCTURES, WHEELS AND BRAKES, RADAR STRUCTURES and many others.

Submit a brief resume of your qualifications and experience. Or write us today for an application blank and further information. Prompt consideration is assured. Address SALARY PERSONNEL DEPARTMENT, GOODYEAR AIRCRAFT CORPORATION, Akron 15, Ohio.

GOODYEAR—The Company with COMPLETE Coverage of the Aeronautical Field



"Hand me my crutches, Mary!

"Doc or no Doc . . . no wounded leg is keeping ME *home on Election Day!* When I was over in Korea, *one* of the big things we figured we were fighting for was the right to vote as we please.

"Just look at that crowd! Seems like *everybody* in town's turning out to vote today. In fact, it's been predicted that more than 55 million people all over the nation will be voting!

"Heard a fellow the other day call it 'National *Beef* Day'. Says he, we *all* beef at one time or another about our local, state, or national governments, or certain people in them. *And today's the day we get a chance to back up those beefs with ballots!*

"Whether we squawk about corruption by public officials . . . about wasteful squandering of our hard-earned tax dollars . . . about government interfering in public utilities and private business . . . about overloading government payrolls with un-needed workers . . . or about government employees with red sympathies—Election Day is the big moment for us citizens to get it off our chests with those votes our Constitution guarantees us.

"I say, thank God we don't live in one of those commie countries where people have only hand-picked red candidates to vote for. Those poor devils just don't get a chance to vote for anybody else. Sometimes, Mary, I think we don't fully appreciate how lucky we are. *We* vote for whom we honestly think best . . . and nobody on God's green earth knows *how* we vote!

"So hand me those crutches, Honey. And get *your* hat and coat on, too. We're going to vote together . . . bum leg or no bum leg."

REPUBLIC STEEL

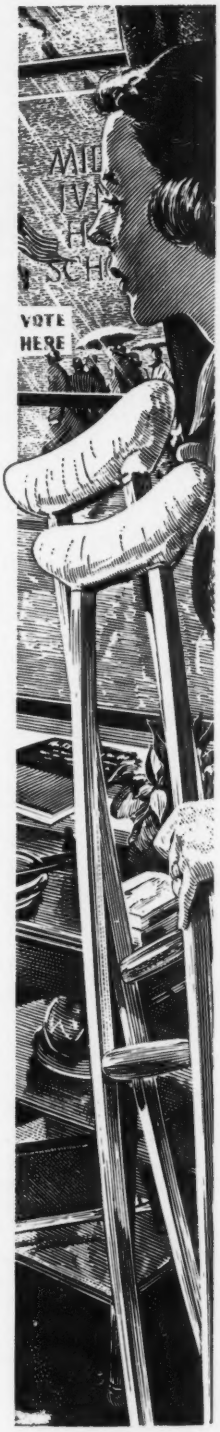
Republic Building • Cleveland 1, Ohio

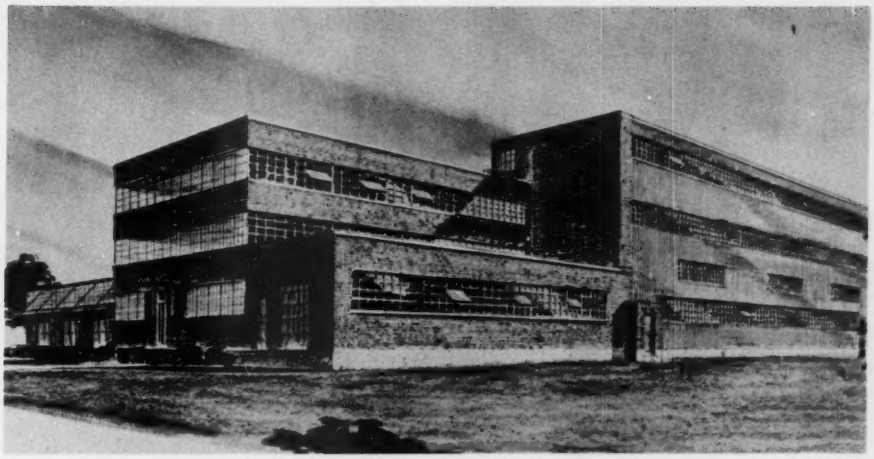
REPUBLIC STEEL

Republic* BECAME *strong in a strong and free America. Republic can* REMAIN *strong only in an America that remains strong and free. To answer the urgent needs of Defense Production, Republic is taking a significant part in the development of Titanium . . . whose structural strength compares favorably with that of many steels, and whose corrosion-resistance ranks it with some of the stainless steels. *Yet Titanium is only 56% as heavy as alloy steel.* No development project (except that of atomic energy) has commanded as much attention and research in so short a period as has Titanium . . . the metal of the future. Keep your eye on Republic Titanium and Titanium Alloys!

* * *

For a full color reprint of this advertisement, write Dept. H, Republic Steel, Cleveland 1, Ohio.





NEW

DOW PLASTICS PLANT TO SERVE EASTERN INDUSTRY

Bright, colorful Styron (Dow polystyrene), the plastic that adds new eye-appeal and utility to many different products, will now be more easily available than ever to the Eastern molder. For Dow, the pioneer and producer of Styron, as well as other plastics, has just completed a large new Styron plant at historic Allyn's Point, Connecticut.

This plant has 2,000 square feet of production space on each of four floors, along with a large warehouse and administration building. Because past experience has proved that rapid growth is a condition normal to Dow operation, the plant has been constructed to allow for future expansion.

This Styron plant is located on an 80-acre plot on the Thames River. Dow also built an 800-foot dock to handle ocean-going vessels. Here they will receive many raw materials from their Texas Plant and ship Styron to Eastern markets and many export markets throughout the world.

This new Styron plant is but one of the many new developments at Dow. The increasing demands of industry for chemicals necessitate continued expansion in every sphere of Dow operation . . . expansion that requires new plants, new technical facilities, as well as a continual increase in personnel talented in varying phases of science.

Dow's Booklet, "Opportunities with The Dow Chemical Company," especially written for those about to enter the chemical profession, is available free, upon request. Write to The Dow Chemical Company, Technical Employment, Midland, Michigan.

THE DOW CHEMICAL COMPANY
Midland, Michigan

DOW
CHEMICALS
INDISPENSABLE TO INDUSTRY AND AGRICULTURE

tech engineering news

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FRONTISPIECE

Hell on Earth

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old cars with

By Dan Brzezenski, '53

(Pictures courtesy of Floyd Clymer's

A 1919 Apperson luxury car ad, appealing to those who led an "elegant life" and were not worried about prices.

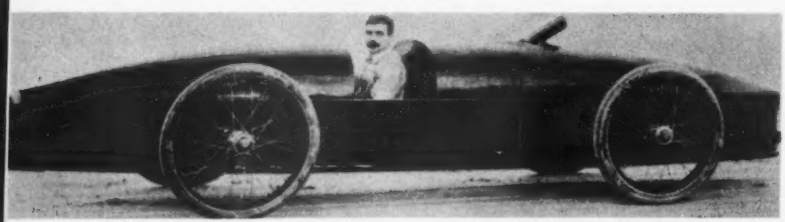
CADILLAC—A $900 TOURING CAR
The single cylinder Cadillac was one of the few early day cars that cranked on the opposite side from most of the "side-winders." The crank was detachable.
The hole where the starting crank was inserted can be seen in the illustration, directly back of the front fender and below the seat.
THE AUTOMOBILE ALL MAKERS HOPE SOME DAY TO EQUAL.
There is no Automobile the equal of the CADILLAC at the price of a CADILLAC.
CADILLAC AUTOMOBILE COMPANY, DETROIT, MICH.

This ad shows how the appeal of the Cadillac has changed in half a century. In 1904 it was a popular car which proudly displayed the price. The legend "There is no automobile the equal of a Cadillac at the price of a Cadillac" would hardly be applied to a luxury car selling in the upper price brackets.

In 1905 this Stanley Steamer established a world's record of one hundred and twenty-seven miles per hour that still stands today for cars under thirty horsepower. The same Stanley later broke its own record, but overturned during the speed test.

In recent years, the restoration and operation of antique automobiles seems to have gained much attention as have the general performance characteristics of automobiles. This trend is noticeable in the increased popularity of "sports cars," and "hot rods." The general output of Detroit does not seem to be able to get a small portion of the attention it used to engender. The reasons are apparent when we compare the uniform product of mass-production against the more distinctive product of several years ago or to that of Europe. The Detroit product, despite many claims to the contrary, is a dependable product which will give many years of good service if given a reasonable amount of maintenance. However, the differences in appearance, performance, and comfort of various cars in the same price classifications are minute, if not negligible. The infinite variety afforded by older cars, contrasted with the present-day uniformity, certainly increases the appeal of the older product.

Over two thousand companies have produced cars in this country. The type of operation varied from small, custom-made models to the mass-production products introduced by Ford. Needless to say, with so many companies producing cars, the competition was cutthroat, with the various companies trying to make a product which was different in some way which would attract the buying public. Thus, if we examine the features of the conglomeration of old cars closely and compare them with many of the "new" ideas being used today, it is hard to find a modern innovation which was not used many years ago. Undoubtedly, the originator of the idea didn't have any realization of the advantages of his product, but this fact still doesn't keep us from noting that most "original" ideas are not original. In this respect we can note how ideas in autos have come in and out of style, much the same as women's fashions. One example would be the V-8 and in-line engines. In-lines were the most popular at first, the V-8's having their first flurry of popularity at the end of the First World War. The in-line became popular again, undoubtedly through the influence of cars such as the Stutz and Chrysler. At the beginning of the thirties the V-8 picked up popularity, lost it slightly just before World War II, and then regained it in full force after the war. Types of valves, L-head or overhead, types of springing and other ideas come and go, each time coming back with more advantages being sworn off onto them.



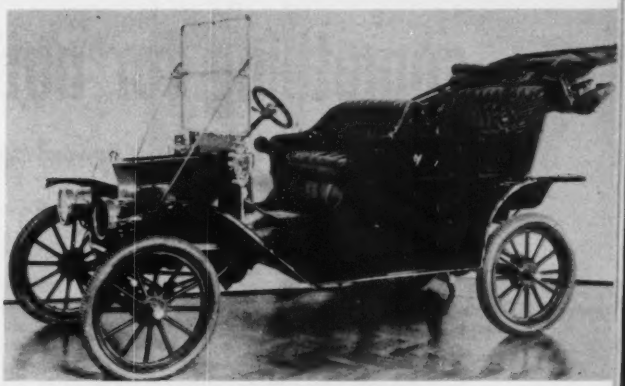
Perhaps the most interesting aspect of old cars is in this variety of concepts on what the automobile should be. At the turn of the century, the matter of the type of propulsive power was not as well settled as it is now. Perpetual motion was considered a perfectly good concept and some amusing methods of gaining it were proposed. One car had two springs of equal strength as the propulsive power. One would drive

"Treasury of Early American Automobiles")

the car while the other would be wound up. The spring being wound up was driven through a gear system so that it would be wound up at a higher rate than the driving spring was unwound. A more practical version of this system was tried where the driver had a set of pedals with which he could wind the spring, and also a gearing arrangement was provided through which he could wind up the spring while going down hills. The most practical method of motive power was quickly decided on as being one of three: electric, steam, or gasoline. The electrics were the most popular for a short time. The reasons were evident. The electric motors could be made more dependable than the early gasoline engines. The lack of fumes and noise was a very good talking point. Simplicity of operation was attained, since no gearshifts were required. However, the operating radius of the electrics was limited. The expense of replacing a set of batteries would often be prohibitive. Since this had to be done every two or three years, it was a great inducement for the owner to buy a steam or gas auto. The electrics had to resort to selling to the higher income brackets and women. As steam and gas became more dependable and simplified, the disadvantages of electrics outbalanced the advantages so that today they are used only in lift trucks and motor trolleys where specialized conditions give them a clear-cut advantage.

Many old-car enthusiasts contend that if a few more of the early experimenters and promoters had pushed steam instead of gasoline propulsion for cars, some of today's cars would be steam powered. Steam did have many advantages. A steam auto was basically simple to operate. Its full power was always available at any engine speed with no gears to shift. It was capable of economical operation. Its biggest drawback perhaps was the fact that the driver had to get up a head of steam before he could move. This may have required a little more planning on the driver's part, but people could have adjusted themselves as they have to other processes. The steam car was certainly popular in the early days. At least one hundred twenty-four companies built steam cars, including some famous names such as Stanley, Essex, White, International, and Locomobile. A Stanley Steamer set a speed record of one hundred twenty-seven miles per hour, which is still unbeaten for cars in the under thirty horsepower class. The White Steamer was the first, and for a while the only, official White House car. Webb Jay in the White Steamer racing car "Whistling Billy" won many early racing events, undoubtedly helping to sell many steamers. However, the inconvenience of the steamer lost out against the gas car, and by 1911 the steamer was approaching extinction.

The gasoline engine slowly became the only type of motive power used. Most of the "greats" in the development and salesmanship field, such as Henry Ford, the Dodge brothers, W. C. Durant, R. E. Olds, and others, chose the gasoline auto as having the most promise and put their fullest effort towards publicizing and manufacturing them. The inherent difficulties of



The original Model T Ford of 1908. It had a two-speed planetary gear transmission, forerunner of the modern automatic gearshift.

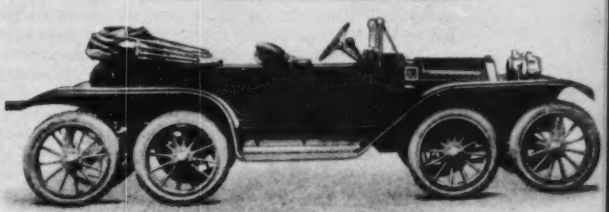
the early gasoline engines were gradually overcome. The public still had to be convinced, and we can read in many of the early advertisements that a certain machine is "the most perfect machine on the market, having overcome all drawbacks such as smell, noise, jolt, etc., common to all other makes of Auto Carriages," or has "A muffler that muffles." The improvement of the engines brought many refinements. Chevrolet brought out a V-8 overhead valve engine in 1917. Buick pioneered the overhead valve engine which they have always used. Stutz used an overhead valve, overhead camshaft engine. In the twenties a tendency developed to rate cars by the number of cylinders. In this period we find cars with in-line twelve- and sixteen-cylinder engines, most of them needing the long hood they hid their engines under. Chrysler pioneered higher compression engines during this period. Another type of engine which fell by the wayside during this period was the air-cooled engine. Chevrolet brought one out in 1922 which almost bankrupted the company. Franklin made the most of the air-cooled engine. They had some trouble with the rear cylinders overheating, but they solved this problem with a motor-driven blower and careful baffling of the engine. To prove their claims of reliability, they ran many road tests in desert areas and hilly country, plus often sealing the transmission in one gear such as first or second. Though

(*Continued on page 24*)

The 1911 Octoauto had eight wheels. This arrangement claimed to prolong the life of each tire to eight times the normal life.

THE OCTOAUTO

AN APPRECIATION BY ELBERT HUBBARD



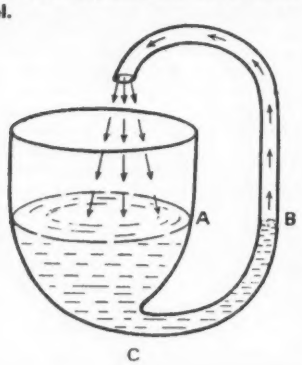
something for nothing

The Inventor's Dream: Perpetual Motion

By Jerry Tiemann, '53

Ever since the beginning of civilization, men of science have been enticed by the incalculable riches and fame which would be theirs if they discovered the Philosopher's Stone or the secret of perpetual motion. The search for these two secrets of nature, one to change lead and other base metals into gold, the other to produce energy for useful purposes indefinitely, started almost as soon as the first attempt at formulating the laws of physics was made. The Ancients did not try to design a self-spinning wheel until they discovered that a weight on the rim could lift an equal one placed closer to the center. Similarly they did not look for the Philosopher's Stone until they believed that matter was made up of air, fire, water, and salt in varying proportions. After this belief came into prominence, it was only natural to inquire why lead could not be changed to gold by, say, adding a little fire and salt and taking out a little air. And it was not long before men

Figure 1. Instead of producing perpetual motion this device led to the principle that liquids seek their own level.



were drawing schemes for lifting one weight with a smaller one by means of a suitable lever in such a way that a cyclical process would produce work. Although the time, money, and effort which went into these schemes may seem to have been a useless waste, it was the search for the Philosopher's Stone which was responsible for the science of chemistry as we know it today, and it was the search for perpetual motion which led to the sciences of thermodynamics and mechanics.

The research of the alchemists was an expensive business, and if not for the support of the richer men of the time, the alchemist would soon have either starved or taken to another profession. It was the possibility of finding the Philosopher's Stone which kept up the interest in alchemy, both on the part of the alchemist and his sponsor. As the elusive stone led the alchemists farther and farther on, more and more was learned about the laws of chemistry.

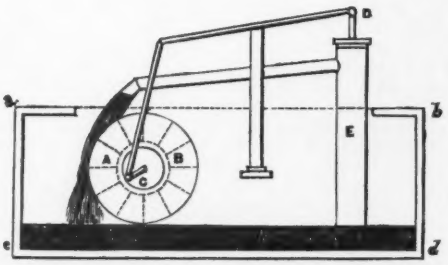
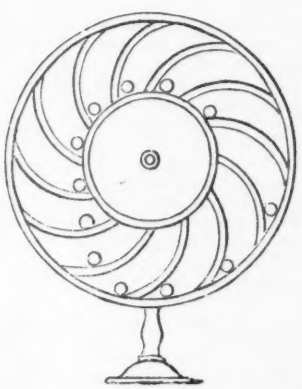


Figure 2. Many attempts have been made to run a water wheel with the water lifted by the very same wheel. On this model, the crank C drives the pump *DE*.

It is much the same story in the case of perpetual motion. It was the ever-lengthening list of failures which led to the Law of Conservation of Energy. To this day there is no mathematical proof of this law. It is one of those very basic assumptions which cannot be proved, but cannot be violated.

One of the very simplest designs for a perpetual motion machine consisted of a goblet-shaped vessel with a tube coming out through the bottom and bending over the top. (See Figure 1.) The goblet was filled with water. Since the large amount of water in the

Figure 3. One of the early mechanical devices used steel balls that shifted their position within a large wheel to attempt to keep the wheel turning forever.



goblet was much heavier than that in the tube, the water in the tube was forced up over the side and back into the goblet again. The experimenter was somewhat surprised when it did not work, but it was this sort of trial which led to the first principle of hydrostatics; namely, that liquids tend to seek their own level.

When this sort of gadget did not prove successful, many schemes for running a pump with a water wheel driven by the water supplied by the pump were conceived. (See Figure 2.) One of these is of special interest since its principle is embodied in a whole class of weighted wheel designs. It consisted of an inner and an outer wheel, both of which dipped into a water reservoir. The water ascended in the cups of the inner wheel, and near the top the water was transferred to the cups of the outer wheel. The water then descended in the outer wheel. The wheel will keep on turning once it is started since the water in the outer wheel has a greater moment about the axle than the water in the inner one. Wheels of this type have also been made with mercury instead of water and with balls rolling in curved slots. (See Figure 3.)

Some of the other early models worked on the principle of capillarity. One consisted of an endless chain made of sponges draped over a triangle whose base was under water. On one side there was a roller which pressed out the water as the sponge emerged, thus making that side lighter. (See Figure 4.) Another model used endless bands which emerged from the water

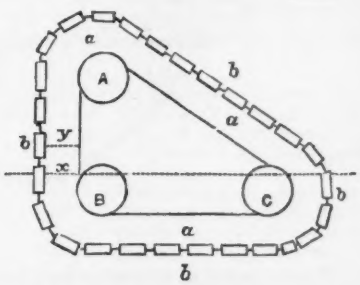


Figure 4. Diagram of a perpetual motion machine using a chain of sponges rotating on a triangular frame. A roller squeezes the water out of the sponges on the right, thus making that side lighter.

through a roller system which kept the water from rising above the roller level. When the bands entered the water, they were held slightly apart so that capillary action could allow water to rise between them and thereby make that side heavier. (See Figure 5.) Numerous devices using capillary action to raise water which is returned over a water wheel have also been tried.

The most famous of the weighted wheel type perpetual motion machines was built by the Marquis of Worcester about 1650. The wheel consisted of forty weights of fifty pounds each hung so that they were one foot farther from the center on the way down than they were on the way up. The Marquis never claimed that the wheel worked, but asserts that all the weights on the descending side are perpetually farther from the center than those on the ascending side, but are equal in number, and weigh just as much on the one side as the other. See Figure 6, drawn to scale, and it can be seen that the weights on the descending side are indeed farther out from the center.

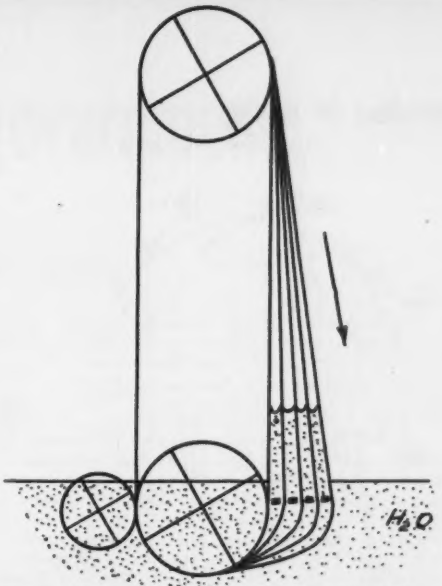


Figure 5. On one side the set of endless bands is squeezed by rollers which prevent capillary action. The other side is pulled downward by the weight of the water which rises between the bands.

There are some other types of machines whose design is based on an endless strap with various objects affixed to it so that the descending side will either be heavier or have a greater moment than the ascending side. The problem encountered in the weighted wheels is that the weights do not hang right until they are considerably past the top. It was reasoned that this effect could be overcome by making the up and down portions of the machine, where the unbalance occurs, as long as is necessary to overcome the effects at the top and bottom. By far the most subtle of these is designed as follows: mount on the endless belt a large

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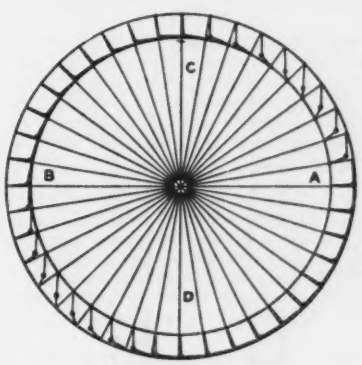
Figure 6. This machine, built by the Marquis of Worcester around 1650, rotates clockwise because the weights on the right hang one foot farther from the center than those on the left.



something for nothing

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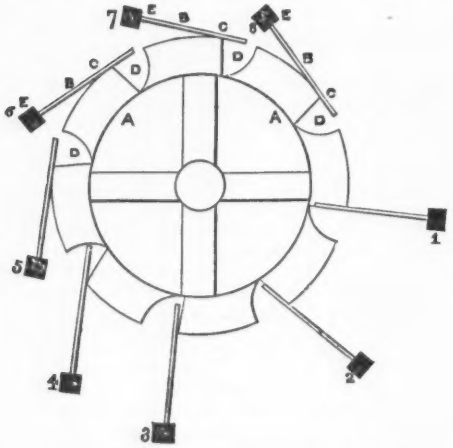
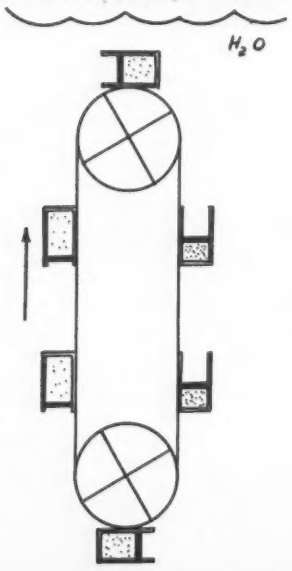


Figure 7. One of the many devices designed to keep a wheel turning by use of shifting weights.

number of cylinders fitted with very heavy pistons. These are pointed in such a direction that the pistons will compress the gas in the cylinder on the downward side and pull down on it during the upward motion. The whole apparatus is then immersed in water up to the upper pulley. The water exerts a greater buoyant force on the gas which is expanded by the weight of the piston than on that which is compressed. Hence one side of the pulley will rise, and the pulley will rotate. (See Figure 8.)

When it became evident that the secret of perpetual motion did not lie in mechanical systems or in water driven gadgets, various other forces were tried. Magnetism was the driving force for a number of models.

Figure 8. The gas is compressed by the pistons on the way down; so the buoyancy on the downward side is less than that on the upward side.



One of the earlier ones had a magnet at the top of an inclined track. There was a small metal ball in this track which was attracted by the magnet at the top. There was a hole in the track immediately in front of the magnet, so that the ball would fall through before it became attached to the magnet. The ball then returned to its position at the bottom of the track by another track. (See Figure 9.)

One of the magnetic machines worked by means of a mysterious black substance which had the property of shielding the magnetic field without itself being attracted by the field. This black substance was painted on one side of a needle which rotated between two magnets. As the needle approached the magnet, the unshielded side was nearest, and the needle was attracted. As the needle passed, the black substance prevented further action by the magnet, and the needle was free to complete its cycle.

One of the more interesting designs for perpetual motion works on the basis of electrochemistry. Down at the bottom of a deep mine some water is electrolyzed. The oxygen is discarded, and the hydrogen is put into balloons which are made to do work as they rise to the

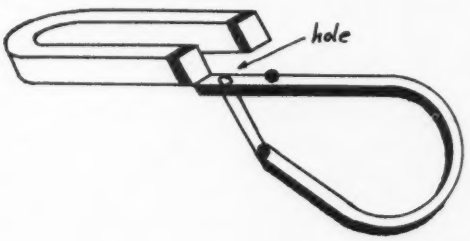


Figure 9. The magnet pulls the ball up the curved track, but the ball falls through the hole in front of the magnet and circulates again around the track.

surface. At the surface the hydrogen is reversibly combined with the oxygen in the air back to water again. There should be just enough energy liberated from the combination process to keep the electrolysis down below going. The water which is formed from the combination of the hydrogen is then lowered back down the mine shaft producing more work in the process.

Throughout the ages there have been numerous claims to success in the field of perpetual motion devices. Even quite recently, gullible people were cheated of their fortunes because of perpetual motion. However, as more and more was learned about the laws of mechanics and thermodynamics, interest in violations of the Law of Conservation of Energy dwindled. There was no way to escape it.

However, at about the same time that inventors were willing to admit defeat, something new came along and interest in a new kind of perpetual motion sprang up. Joule had shown that heat and work were equivalent and that heat could be transformed into work without violating the law of Conservation of Energy. The next question was could the heat of some large

(*Continued on page 24*)

scientists and the government

By E. U. Condon

Reprinted from *Bulletin of Atomic Scientists*, August, 1952

The topic, "Scientists and the Federal Government," is an important one because, each in its own way, both science and the federal government play dominating roles in our lives today. Therefore, the interactions between them must necessarily be of profound interest to us. I suppose that, for better or for worse, it will be a long time before we live again under circumstances in which either organized scientific research, or the actions of the federal government, will affect our lives as little as they did, say, a half-century ago.

What are scientists, and what do they do? Scientists are persons who devote themselves to planned and controlled study of natural phenomena with the object of increasing our understanding of the world in which we live. Many of them are principally motivated by the thrill and excitement of doing this. Many more derive a deep religious satisfaction from the scientific study of nature; it is one way to know more of the Creator, to devote oneself to a study of what He has created. Others are motivated by the useful applications of the understanding of nature which science gives us, with varying degrees of concern about whether these applications produce good or evil results in the use which society makes of them.

These additional considerations of motive are foreign to science as such. A man is a good scientist if he makes honest and effective use of the techniques of planned and controlled study of nature, without regard to his deeper personal motives for doing so, and also without regard to what use he or others may make of the knowledge so gained. In this sense science as such is ethically neutral. But the scientist is also a human being with responsibilities to God, and in this sense must be concerned with the social conditions in which he lives and in particular with society's attitude toward science, and the use his community makes of the results of science.

Scientific research is supported by individuals, industrial and governmental groups, partly out of a genuine desire for abstract knowledge, but mostly from the desire to make some sort of use of the results obtained. We live in a world of vocational specialization and today most scientific research is carried on by full-time professionals who are employees of others.

This fact immediately raises some ethical questions. Suppose a scientist is employed by his government to work on some matter which is revolting to the consciences of most of us, let us say, on techniques of offensive bacteriological warfare. Suppose he is eminently successful in developing effective techniques. Suppose his government uses them in warfare. Is the scientist who made this possible particularly reprehensible? Or is not the guilt for the evil done shared by the social group as a whole, or, more particularly, by those officers of government who made the policy decision which set the scientist to work on this task?

We come here face to face with a kind of question to which different men's consciences will give different answers, just as different individual Christian pacifists will permit themselves varying degrees of involvement in military affairs.

My position on this is definite: When society, or more particularly the government of any national group, equips laboratories and sets men to work on development of new weapons of any kind, the moral responsibility for this act must be assumed by the group as a whole, and cannot be put on the shoulders of the individual scientists who are assigned to such work.

I maintain that we are all in this together, and that neither society as employer nor scientist as employee can escape the moral responsibility attaching to their acts.

There are many signs that this point is not well understood. In the April issue of the *Bulletin of the Atomic Scientists*, General Omar Bradley is quoted, I would hope incorrectly, as having said:

"We have too many men of science, too few men of God. We have grasped the mystery of the atom and rejected the Sermon on the Mount. . . . The world has achieved brilliance without wisdom, power without conscience. Ours is a world of nuclear giants and ethical infants. We know more about war than we do about peace, more about killing than we do about living."

Here is a striking example of the mistaken antithesis between science and God. We are not confronted with the choice that is implied here: One can be a man of science and also worship God; one can grasp the mystery of the atom and even more fervently strive to follow the teachings of the Sermon on the Mount; one need not be an ethical infant because he is a nuclear giant.

It is difficult to learn from a study of the federal

(*Continued on page 40*)

strength in union

Why Engineers Organize

By Roger I. Wilkinson

Past Chairman, Conference of Professional Technical Personnel of Bell Telephone Labs., Inc.

The Challenge

"Organizations of professional engineers for collective bargaining in any form are to be deplored, although their existence for the present, may be condoned under certain circumstances. . . .

"When employers generally are persuaded that professional employees must be viewed as individuals and not in groups or classes, then National Society of Professional Engineers may condemn collective bargaining by professional engineers, without qualification. In the meantime we advise the young engineer that the existence of collective bargaining by professional engineers in an industry jeopardizes his professional status."

Thus did the Board of Directors of the National Society of Professional Engineers in June 1950 attempt to outlaw employee engineers who band together to discuss with their employers such matters as working conditions, remuneration, and personal grievances. Nor has the NSPE been alone in its categorical stand. In recent years there has appeared a continuing succession of pronouncements, editorials, and articles decrying the increasing boldness of employee engineers in speaking out as to what their "proper treatment as professionals" should be. A number of "elder statesmen" of the profession have wrung their hands at these misguided actions of their brother engineers, lamenting the lack of pride in self and the unwillingness of the younger generation to accept the advice of the wise old heads as just one more proof (as if any were needed) of today's deteriorating morality. Other advisors have sought to restrain engineers from "organizing for their mutual benefit" by pointing out that any such association is but one step removed from a labor union — and everyone knows what a sad day it would be for engineers if they ever got mixed up with labor unions! Professionalism, which is the *sine qua non* of every true engineer's ambition, would vanish, and we should fall from the high position of serving society to the crass materialism of the collective bargaining table. The negotiating committee would be substituted for the traditional intimate relationship of client and consultant, and engineering might well be reduced to the status of a trade. In short there is hardly anything good which can be said for engineers acting collectively as opposed to their enviable position as free individuals.

But the indisputable facts are that in spite of all these appeals to reason and threats of excommunication, there has been a rapid increase in the formation of employee-engineers associations throughout the country in the past few years. In fact there soon will be no medium-to-large employer of engineers and scientists in the United States where there has not been formed some kind of association for assessing employees' views and grievances and presenting them in one fashion or another to the management.

A recent listing shows the existence of nearly seventy such employee-engineer organizations, and the number increases daily. Some groups are informally set up as "sounding boards." Others have negotiated contracts with their managements but are not NLRB certified, while still others — and these are a large group — are honest-to-goodness labor unions "and proud of it."

How could this revolution in attitude and thinking have happened in so short a time? To get at the answer we need to examine the new engineering society. The new society which exercises a profound effect on all our lives, arrived so quickly and quietly that its strange ways stole over the country before we were aware of its dangers and shortcomings. In any event it is here, and very likely to stay a long while. The new society's distinguishing characteristic lies in its concept of organizing men for joint work. Its elements are "integration" and "specialization." Men work now in groups, the individual worker is relatively unproductive. He has not only lost the ability to free lance in the old sense and make a living for himself by his own tools or hands, he has also lost the pride and social prestige of individual accomplishment. The change to mass production in the last forty years is perhaps the greatest of the revolutions in modern history, and accomplished in by far the shortest time.

We know the development well. On the one hand, large aggregates of capital were required to assemble the plants and machines to take the fullest advantage of the mass-production principle. To integrate the intricate processes involving men and machines, power was concentrated in the hands of a few managers. Sometimes they used it well; and sometimes poorly. To offset these new and fearful dangers, it was natural and inevitable that the workman, stripped of his individualism, both economically and psychologically,

(*Continued on page 28*)

Figure 1. Typical engineer salary progressive curves.

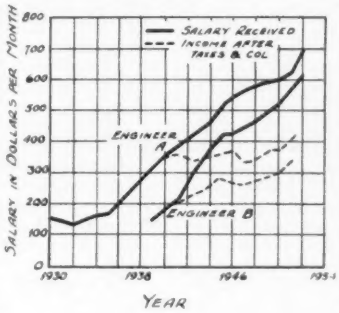
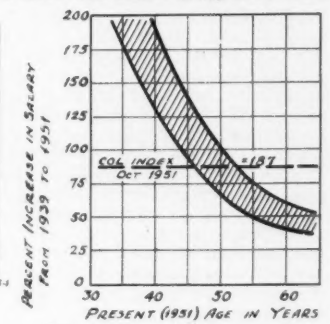


Figure 2. Comparison of salary increases with cost of living since 1939.



the unseen network

Pipe Lines Keep Vital Materials Flowing

By Tom Cantrell, '55

A huge portion of a modern nation's transportation complex is completely out of sight, buried under the ground. Much of this unseen network consists of pipe lines, used to transport three major materials: natural gas, crude oil, and refined products. Natural gas lines run from the gas fields to heavily industrialized areas. The crude oil pipe lines run from the oil fields to refinery districts. Oil product lines connect refineries with industrial marketing centers. Since the huge oil and gas fields are centered in the Texas Gulf Coast area, while our great industrial districts are in the Middle Atlantic and Middle West states, this country has a number of long distance pipe lines. Over six thousand miles of pipe line was completed in the United States during 1951, and more is needed.

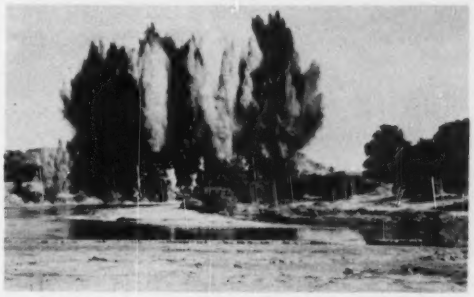
The laying of a pipe line may appear to be a relatively simple job. There are many problems involved, however, which are anything but simple. The prime consideration in the design and construction of a line is to place the pipe in stable surroundings. It is necessary to have the steel wall of the line free from all stresses except those imposed by the pressure of the liquid or gas flowing in the pipe. Unstable surroundings, then, are those which cause outside stresses on the pipe.

Eroding hillsides may uncover a line and cause a break. Ground which heaves and settles with temperature changes creates stresses on pipe passing through it. Backfill, the material used to fill the ditch after the line is laid, can damage the pipe if it is rocky or filled with clods.

River and stream crossings pose the major problems

Laying pipe in rugged country requires both modern machines and old-fashioned dynamite.

to the engineers planning pipe lines. Streams that are high on a watershed are nearly dry most of the time, but in seasons of heavy rain become raging torrents. They may suddenly deepen or change course. Streams crossed at lower points in the watershed often meander over a large sandy area between higher, well-defined



A tremendous blast clears the way for another section of the gas mainline.

banks. At flood conditions, the water may uncover and break a line. A sudden change of course by the river may place stretches of the line under water which were not buried deeply enough, or otherwise prepared to be submerged.

In planning a line, therefore, the most economical and dependable route is the objective. Economics also demands as short a route as possible, although a longer one may be chosen if it affords better soil conditions than the straight line distance does.

The actual laying operation consists of clearing the right of way, digging the ditch, preparing and lowering the pipe, and then covering it.

Conventional earth-moving equipment is used in clearing and grading the land, but huge ditching machines have been developed which literally chew out a ditch of the required width and depth. After the ditch is dug, it is cleaned out and "padded" to receive the pipe.

Merely getting the pipe on location is a huge traffic problem which requires careful planning and timing. The pipe is then cleaned of scale and rust, and given a protective covering. The covering serves to keep moisture away from the steel of the pipe, thus retarding chemical and electrolytic corrosion. Several types of coating are used. One is coal-tar enamel reinforced with fibreglas. Another is specially compounded cement reinforced with wire screening. This type is useful at stream crossings, as it increases the weight of the pipe, helping to anchor it. The joints in the pipe are welded in most cases. The pipe is now lowered into the ditch and covered. If it is at all feasible, backfill or covering which is free of rocks or clods is used.

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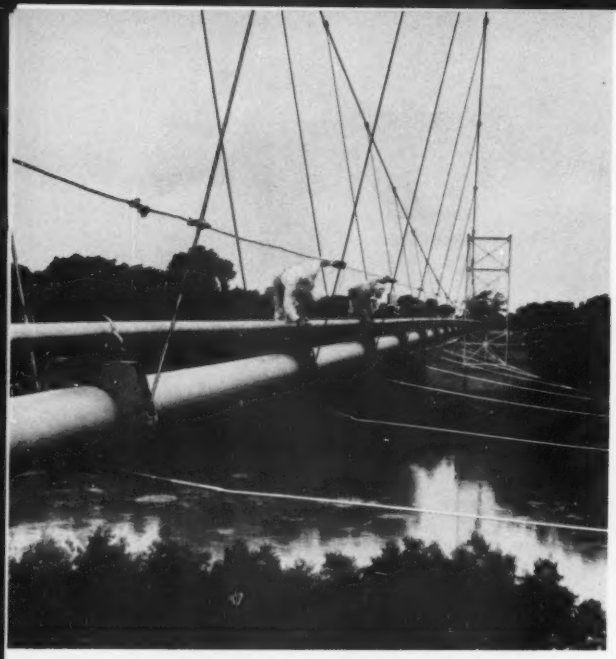


The only traffic this suspension bridge carries is gas. Pipe lines cannot be stopped by rivers.

the unseen network

(*Continued from page 13*)

In order to keep a pipe line in operation, a number of varied maintenance problems must be considered. First, the actual condition of the pipe has to be determined and maintained at a satisfactory level. The mechanical equipment, such as pumps, pump engines, lighting plants, storage tanks, and building, must be kept up also. The control and communications equipment which includes microwave radio, telephones, automatic electric controls, aircraft, and automobiles are also essential to pipe line operation and must be kept in good condition.

Maintenance of the pipe itself includes prevention of breaks and repair of breaks that do occur. Preventing breaks is closely tied with soil conservation, since undermining gullies and rampaging streams are the major causes of breaks in the line. It is therefore the policy of the transmission companies to support and promote soil conservation programs in the areas the pipe line traverses. These programs consist of farm ponds, hillside reforestation, flood control reservoirs, and other devices to prevent quick run-off of water and erosion of soil. In addition, an effort is made to keep a stream within its banks in the immediate vicinity of a crossing. This is accomplished by use of wood and metal jetties and bankside vegetation, like willow trees.

If the steel of the pipe comes in contact with moist soil, galvanic corrosion of the steel results. This problem is attacked in several ways. First, the pipes are coated with materials designed to keep the water away from the steel. However, these are never perfect and may be damaged by tree roots, rocks, and other physical obstruction. Direct electric current is used to overcome the alternate anodic and cathodic condition of pipe lines caused by the corrosive soils. Under some conditions sacrificial magnesium anodes or junk pipe are used along the line.

The insides of the pipe may become coated with wax, rust scale, or other deposits. These are cleaned out by scrapers which are carried through the pipe by the moving liquid. Recently these scrapers have been tagged with radio-active materials so their progress through the pipe may be traced with Geiger-Mueller counters. Special cements for relining worn pipes have also been developed.

Patrol aircraft equipped with two-way radio have proved valuable in spotting breaks and danger points along the lines. They make inspections more frequent and speed restoration of service after breaks by finding them quickly.

The principal operation performed by a pipe line company is, of course, pumping the oil or gas through the line. Pumping stations are located at intervals along the line determined by the hills the products must be pumped over, and the volume of flow desired. At the pumping stations, there are batteries of natural gas or Diesel engines driving the pumps. However, where electricity is cheap, the pumps may be driven by electric motors. Some of the early lines used steam-driven pumps.

In refining processes, water is often put into the oils for various purposes. This water causes headaches when the oil is pumped through the line. Rust and scale formation caused by the water shorten pipe life. This problem is solved in one of two ways: inhibitors or dehydration units. Inhibitors are chemicals dumped into the line which coat the walls of the pipe or prevent rust in other manners. At dehydration plants, the product is pumped through beds of activated alumina, which remove the water.

Automatic controls have been developed so that one central station may route a product from tank to pipe line with no manual operation of valves.

Dependable communication between pumping stations and maintenance facilities along the pipe line is essential to successful operation. Recently, microwave radio networks have been set up along the routes of the pipe lines. These have the advantage of using directional type waves, so there is less interference and nighttime fade. The microwave systems are less susceptible to storm damage than telephone systems. Conventional two-way radio is used between stations, maintenance trucks, and patrol aircraft.

The future looks bright for the pipe line industry. Cities have a large and growing appetite for natural gas. As the newer oil fields are enlarged, more crude oil pumping capacity will be needed. With technological advances in maintenance and operations the capacity of existing lines will also increase.

Pipe lines break in the most inconvenient places. Fortunately, few repairmen require diving suits.

space, time and einstein

The Special and General Theories of Relativity

By Rudolf Kalman, '54

On the north side of Wood Dormitory (East Campus of MIT), there may be found inscribed in the concrete sidewalk, à la Hollywood, a very important equation, which represents one of the first physical "truths" entrusted to freshmen and likely to accompany them throughout their sojourn at the Institute. It is simply

$$F = ma \qquad (1)$$

Even though this equation serves as a pillar upon which much in the engineering arts rests, its validity has long ceased to be absolute. The why's and wherefore's of the situation are known as the theory of relativity.

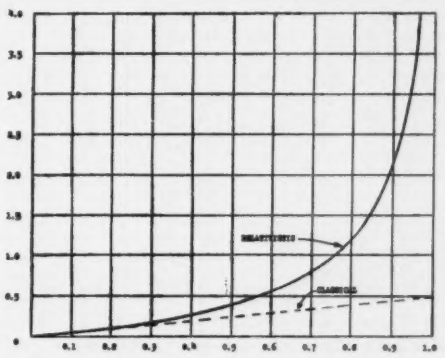
The central results of the theory, due to Einstein (1905, 1951) are twofold: first, mass is no longer conceived to be a constant as is tacitly assumed in equation (1); second, and this is much more abstract, our ideas concerning space and time appear in new light. It is necessary to make a rather sharp distinction between the "special" (1905) and the "general" (1915) theories of relativity; the first is primarily concerned with setting up a system of mechanics in which the velocity of light is an absolute invariant (maximum); the latter is an ambitious attempt to interpret natural phenomena (in particular, gravitation) in the universe by means of a geometrical model.

An essential concept in connection with the discussion that follows is that of *reference frames*. In order to be able to describe physical processes in mathematical terms, it is necessary to establish (arbitrarily) some kind of a coordinate system. Although there are no constraints on the mathematical choice of such reference frames, the mathematical choice of such reference frames, the physical interpretation of different possible choices is significant. For instance, if the reference frame is a railroad car moving with a *constant* velocity (or the earth moving around the sun), no experiments performed *inside* this frame will be able to reveal the fact that the reference frame is moving; the situation is quite different if the reference frame is, say, a jolting railroad car (nonconstant velocity). It is natural to choose as a particular reference frame K' one in which the laws of nature are expressible in the most simple form. We may call such a frame an "inertial" system. The essential question is now how the events in frame K' may be expressed in another frame K. The distinction between constant-velocity and accelerated reference frames is in fact the dividing line between the special and general theories of relativity. With regard to the first case, the "principle of special relativity" may be formulated as follows: If K is an inertial system, then every other system K' which moves uniformly and without rotation relatively to K, is also an inertial system; *the laws of nature are in concordance in all inertial systems.*

The basic problem is therefore this: If we know the nature of motion in frame K (given, say, by the Cartesian coordinates x, y, z, and t), how can we relate this to another frame K', which moves with uniform translation with respect to K? In classical mechanics, this is solved by unconsciously making two hypotheses: (a) the time is absolute (the time relative to frame K is the same as the time relative to frame K'); (b) length is absolute (an object having length s in frame K has the same length in K'). These ideas were represented in classical mechanics by the Galilean transformation; this means simply that if the axes of K and K' are parallel and K' is moving with velocity u with respect to K, along the X-axis, we have

$$x' = x - ut \qquad z' = z \qquad (2)$$
$$y' = y \qquad t' = t$$

These equations have a very simple physical meaning: if a man is walking forward at 6 mph. in a train traveling at 40 mph, his velocity with respect to the ground



A comparison of the predictions of classical and relativistic mechanics. The vertical axis represents a quantity proportional to the kinetic energy of a particle. The horizontal axis represents the ratio of the velocity of the particle to that of light. Experiment has borne out the relativistic prediction completely.

would be 46 mph. But the Galilean transformation fails when applied to electromagnetic phenomena (Maxwell-Lorentz equations). The most striking difficulty involved in the theory based on the Galilean transformation is that the velocity of light in vacuum appears to be an absolute constant (a maximum): observations made with the earth as a reference frame are not influenced by the translational velocity of the earth. This conclusion was "nailed down" by the Michelson-Morley experiment; its validity is no longer questioned.

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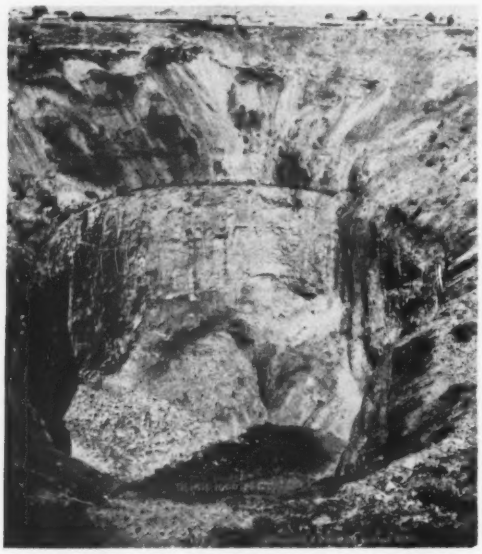
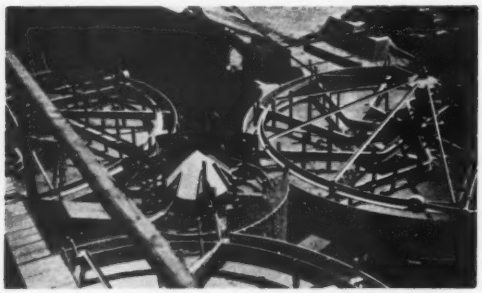
This crack in the ground was once filled by a diamond-rich Kimberlite dike.



The Kimberly pipe in South Africa has for many years been a source of diamonds as evidenced by the large amount of rock material that has been removed.



After having been crushed the Kimberlite is washed in these tanks where the heavier constituents of the rock including diamonds collect at the bottom.

rich

The Origin, Occurrence and

By Herbert S. Jacobson

The diamond is familiar to all as a gem of sparkling source or the manner in which

Diamonds are found in many parts of the world, but the most extensive deposits are in South Africa, where most of today's diamonds originate. Other diamonds come from India, the oldest known producer, the Belgian Congo, Brazil, Borneo, and the United States. In some localities the diamonds are found in stream beds, though this is not their primary source. Most diamonds are found in a kind of volcanic rock called Kimberlite. This Kimberlite intrudes into zones of weakness within the earth's crust, forming three different kinds of rock formations which may or may not be associated with each other. The first and perhaps least common of these formations is a sill, which is a horizontal layer of solidified magma lying between layers of older rocks. The Kimberlite sills in which diamonds are found are usually not more than ten feet thick but may cover a wide area. Diamonds are also found in dikes, which are simply vertical layers of solidified Kimberlite that may be visualized as filling cracks in the earth's outer crust.

Despite the fact that large amounts of Kimberlite may be found in sills and dikes, most diamonds are mined from another type of formation known as a pipe. In general, a pipe is a roughly circular formation which is shaped like a funnel. It goes down into the earth to unknown depths. Actually it is nothing more than a feeder pipe for what may once have been a volcano. The diamond-rich Kimberlite pipes are believed to be the result of an explosive liberation of gases within the earth. It is also believed that these gases pushed the Kimberlite up into the pipes after it had already partly solidified. It is for this reason that no volcanic cones of Kimberlite have been found. Some of the larger Kimberlite pipes are about one-quarter mile in diameter. These pipes therefore contain a tremendous amount of Kimberlite and diamonds. However, the diamonds make up an infinitesimally small part of the volume of the Kimberlite. More specifically, one hundred tons of Kimberlite yield ten to twenty-five carats of diamonds. (One carat equals two hundred milligrams.) Thus, diamonds account for less than one-millionth of the Kimberlite.

While there is no mystery as to where diamonds are found, their origin remains somewhat of a mystery even after more than half a century of intensive research. It is of course known that the diamond is a form of carbon that has been crystallized under extremely high pressures and temperatures. However, no one knows where and how this crystallization took place though several theories exist. One theory is that the diamonds were crystallized deep within the earth and that the rocks within which they crystallized were later dissolved by the Kimberlite. This theory is based on the assumption that the diamonds were not originally a part of the

earth

Mining of Diamonds

brilliance and great value. Not so well-known is its it is extracted from the earth.

Kimberlite magma. A second and more generally accepted theory is that the diamonds were originally a part of the Kimberlite. This uncertainty as to the environment where the crystallization took place is augmented by the lack of knowledge about the actual mechanism of diamond crystal formation. About the only facts that are known about the process is that diamonds crystallize at a temperature of 1200–1300 degrees Centigrade and that iron is in some way connected with the crystallization. Though much remains unknown about the manner in which diamonds are formed, a large amount of information has been obtained by laboratory experiments with the kind of high temperatures and pressures that create diamonds.

Although the origin of the diamond is not well-known and is of rather academic interest, the way in which it is extracted from the earth is of more practical importance. Most diamond mining occurs in the Kimberlite pipes described above. The solidified Kimberlite in the pipes has a blue appearance and is therefore known as blue ground. This blue ground is removed from the pipe in two ways. When a pipe is just beginning to be exploited, the blue ground is simply removed from the top of the pipe by blasting with dynamite and removing the loosened rock with suitable earth-moving equipment. This method becomes impractical after a pit 250 to 400 feet in depth has been dug. At this stage a second mining technique is begun. First a vertical shaft is dug near the pipe and then horizontal tunnels are dug from the shaft toward the pipe at several depths as shown in the accompanying diagram. The blue ground is then removed through these tunnels and the shaft. It is then brought to the surface, and is ready to be relieved of its valuable diamond content.

The first step in this extraction process is to spread the blue ground out on a flat surface and expose it to sun and rain for a few months to allow the Kimberlite to disintegrate. Next the blue ground is further broken up by mechanical crushers. Sometimes the Kimberlite emerging from the shaft is fed directly into these crushers instead of allowing the sun and rain to do their work. The crushing is followed by a series of washings with water which removes most of the lighter constituents of the blue ground. Washing is accomplished in large tanks where water and blue ground are agitated together. The heavier portion of the blue ground, which is the one containing the diamonds, sinks to the bottom while the remainder is removed from the tank in the form of a thin mud. The denser material that has sunk to the bottom contains a number of heavy minerals and diamonds and is subsequently treated to remove the diamonds. It is interesting to note that

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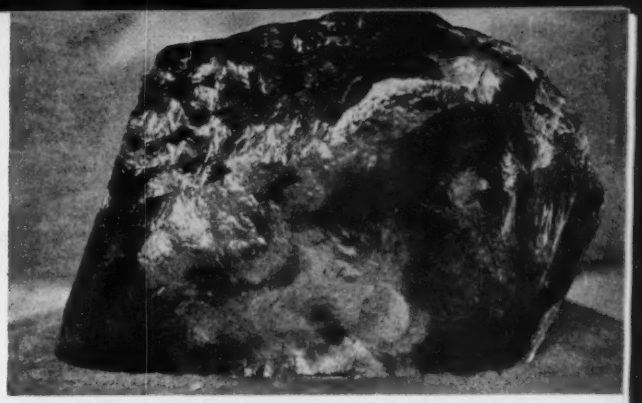
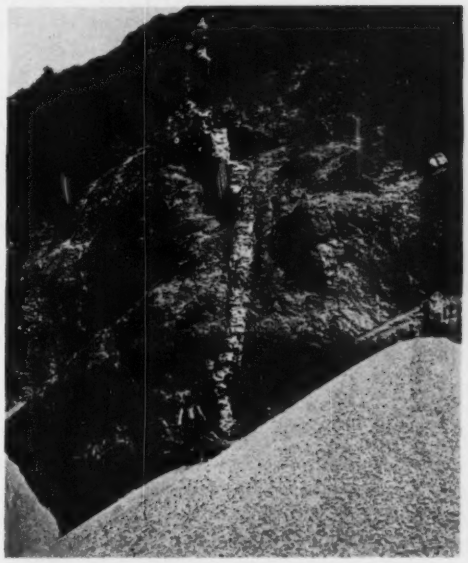


The Cullinan diamond, the largest ever found, is depicted here actual size. Before it was cut into Britain's crown jewel gems it weighed over a pound.



The narrow vertical band of light-colored rock shown here is a Kimberlite dike and a potential source of diamonds.

An open pit mine for the recovery of diamonds, such as this one, seldom exceeds a depth of 400 feet.

tech engineering news

Professional Journal of the Undergraduates of the
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from the editor's notebook

The middle of the term sees the freshman becoming accustomed to M. I. T., the sophomore trying to "do better" than last term, the junior completely involved in professional work, and the senior on the proverbial last lap.

In general, the ideas we have change somewhat with the years. Maturity offers us responsibility, the impending horizons cause us much eye-strain, in anticipation, and the world about us has more meaning — we are actually a part of it, all of a sudden.

These and other innovations bring to focus a society in which we find ourselves with a task to perform — to be good citizens, successful professional people, fine family men (and women), and so forth. Now then, the question arises, "Are we fully developing all our potential, so as to meet this task?" Certainly not, if we thought we were it would be either through ignorance or hypocrisy. The lack of self-examination leaves us with a certain smugness that is almost pleasant, and so we continue on our merry way.

The answer lies in what is generally spoken of a variety of experience. By this we mean participation in many occurrences, adventures, and intellectual explorations — music, art, literature, and so forth. It has become very evident to those of us who have been at the Institute for a number of years, as it has to the Class of 1956, that study is the main purpose, and rightly so. But lest we forget that the world is not all on paper, or in classrooms. There are many cultural sights in and near Boston, many activities at the Institute which offer anyone with a few hours a week to spare, a fine opportunity to become a working part of an organization, and, as was pointed out in the first convocation, there is an opposite sex.

In addition to this business of variety of experience, we should also develop a state of mind in which originality and individuality are motivating factors. In this framework, we will know what we ought to do with our time, how we should apportion it, and what should be expected of our efforts. The combination of doing and thinking in an individual way will prove to your advantage. It will give you the public asset of good reputation, and the private asset of sound character.

The memory of four years spent at M. I. T. will not be nearly so pleasant if we choose to dedicate ourselves exclusively to studies. The recollection of an afternoon spent in our music library, or one on the Charles, dinner at Durgin-Park, your beer parties and bull sessions, a night at the "Pops," and the evening with the girl that gave you a "hard time" (and the one that did not) will all form shadow pictures for you in the years to come.

N. R. G.

the technologist as man and citizen

A Response to Dean Bowditch

By F. T. C. Bartels, '53, and Sherwin Kalt, '53

It is encouraging to find that the administration of M. I. T. recognizes the important place which a philosophy of individual freedom must occupy in any educational system, and is willing to express its views, as Dean Bowditch did in the October issue of *T. E. N.* Inspired by Dean Bowditch's implied invitation, we take pen in hand. . . .

Dean Bowditch attempted to answer three questions: Is the modern engineer or scientist narrow-minded, lacking in social development? What is individual responsibility? What is, and should be, the role of student government at M. I. T.?

Dean Bowditch correctly recognizes that the answers to these questions must stem from a clear understanding of the purpose and philosophy of education at M. I. T. He states that "At M. I. T., the Faculty is reaffirming the central importance of the individual student, is becoming increasingly concerned with the importance of developing the whole man and increasingly aware of the futility . . . of turning out a superbly trained intellect in a man devoid of emotional stability, ability to live and work with his fellow man, and any sense of the moral, spiritual ideals of his school or his country." Of course, he recognizes that we are far from reaching the ideals expressed in that sentence. Nevertheless, we must agree that the above is an excellent statement of a sound concept of education. Further, Dean Bowditch states that the answers to these questions may be found "in a restatement of eternal, moral, spiritual truths in modern terms and the development of a modern formula by which these eternal truths can be applied to modern conditions." We do not doubt that a sense of emotional stability and responsibility can come only from a philosophy of life which recognizes the existence of certain basic truths and morals.

Dean Bowditch apparently believes that these basic truths are the "common ideals" of our society. Now, Dean Bowditch makes many statements about individual freedom and responsibility, and many other statements about common ideals. However, we find no statement of the relationship between the two, other than what seems to be an assumption that the two (at least in responsible, mature individuals) are necessarily identical. Surely, Dean Bowditch did not mean to imply this.

After all, "common ideals" are only a statement of the consensus of the group; by and large, a sort of statistical average. They spring from an agreement between the individual philosophies of the members of the group. If individual members of the group are free to develop and mature their own thinking along the lines which seem best to them, and to pool their conclusions in the common ideals of the group, they will produce common ideals of which each member may well feel proud, and to which he can freely give allegiance. Thus, the development of vital common ideals depends, first, on the members of the group having mature and deeply felt personal ideals; and second, upon each member being able to contribute to the process of forming these common ideals. As Dean Bowditch recognizes, truths may be eternal, but they are not static; they must continually be reinterpreted by each group, and by each individual, in order to be effective.

However, the development of a philosophy in the individual student is not merely a matter of indoctrination. This century has seen many ideas of the past cast aside. The student has developed his mind in an atmosphere of doubt. It would seem natural, if he is at all sensitive, for a person to question even the ideals of truth or justice which we feel to be basic. It is only through such questioning that he may arrive at a mature and deeply felt philosophy. In such a process it would be wise not to put too much emphasis on common ideals. No man will feel personally responsible for a set of ideals which is thrust upon him, no matter how fine they may appear to others. We often see the results of such conformity in the references to certain "common" ideals by members of student government, but which, unfortunately, seem to be without meaning in governing their actions.

It is often assumed that student government is necessarily democratic, while government by the administration is autocratic. However, it is important to note that student government has often lacked the maturity and responsibility which the administration has displayed in the past. Certainly, we find that a group composed in part at least of students interested solely in their personal benefit, lacks the humanity and warmth which many of us remember from our contact with Dean Baker. The immature handling of power by students interested primarily in the satisfactions of "working with people" which they might better phrase, "working on people," and wielding power for its own sake can certainly be as arbitrary and autocratic as any dictatorship. While we doubt that student government can destroy individual freedom by the dictatorial exercise of power, lack of tolerance by a majority of the student body can destroy the self-reliance and inventiveness of which democracy depends, and substitute a shallow conformity to "common" ideals.

Dean Bowditch asks, "Are we training specialists who . . . are inadequately trained to use their specialized knowledge for the benefit of society and to play a significant role as citizens?" We do not believe that M. I. T. is *training* narrow-minded specialists, but there may be some question as to whether M. I. T. is allowing room enough for its students to become broadminded. As we pointed out before, the attempted imposition of a common set of ethics, readily learned, can close the path to deeper thought and questioning, which might have led to firm convictions. Isn't it possible that despite the glibly stated ideals, we are training specialists who do not understand the satisfactions to be obtained from working for the benefit of society, since they have no real faith in its ideals?

At the present time many people fear for the continuance of freedom in the West, not only because of the threat of totalitarian powers abroad, but also because these threats may lead to the extinction of individual freedom in a drive for complete uniformity.

The success of such a drive would destroy the type of life we know today. Dictatorship is dictatorship, whether the dictator is one man or a majority. We must not allow ourselves to be coerced into giving up our individual convictions by well-meaning people who argue that strength and responsibility require that everyone have identical ideals. After all, there is no group which is more in agreement than a mob—and no group which is weaker or more irresponsible. Although we should cherish those ideals which we truly hold in common, we must also allow individuals to question and test those ideals, a process which will only strengthen those ideals which are valid.

Dakar, capital of French West Africa, is one of the latest cities to be connected to the United States through Bell System Overseas Telephone Service. Initial period rate is only $15. You can talk to some 90 countries and territories from your telephone.

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It has kept on shrinking over the years till now such overseas calls are commonplace. In 1951, nearly 900,000 were made over Bell System facilities. Today you can speak to some 90 countries and territories, 96% of the world's telephones. Dakar, French West Africa, is one of the latest additions to the list.

On this 25th Anniversary of Bell System Overseas Telephone Service, we are busy working to make the record of the next 25 years even better. This never-ending effort to find better ways calls for the best engineering and scientific minds available. Such continued research provides constant opportunities for enterprising, talented college graduates.

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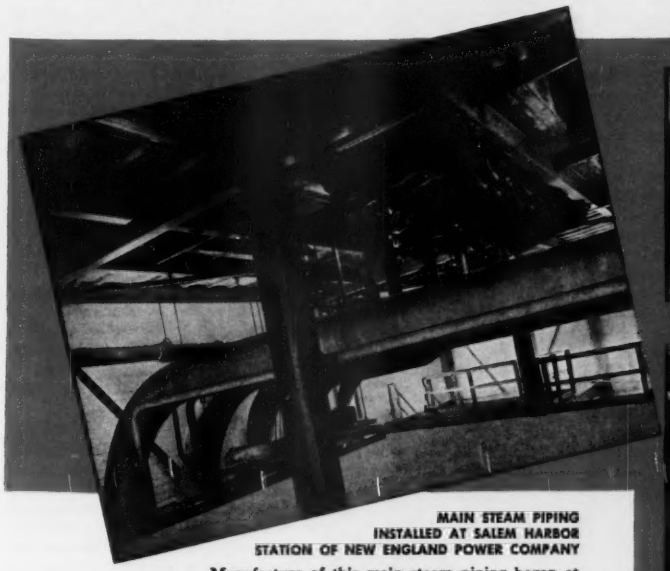


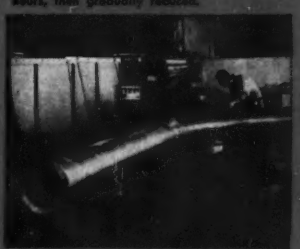
MAIN STEAM PIPING INSTALLED AT SALEM HARBOR STATION OF NEW ENGLAND POWER COMPANY

Manufacture of this main steam piping began at Pennsylvania Forge Corporation as 20-ton alloy-steel ingots (2½% chrome, 1% moly steel). Four days' forging changed the ingots into solid bars 30 ft. long, with outside diameter of 15½ in. Boring, turning, sizing and finishing followed.

Bending furnace raises pipe temperature to 2000°F in 3 hours, 40 minutes. Thermocouples and pyrometer measure pipe temperature.

Skilled team completes bend in six minutes. Inside surface temperature dropped about 100°F.

Bend being loaded into furnace for stress relieving. Heat maintained at 1425°F for 4½ hours, then gradually reduced.



Ultrasonic inspection of weld after cleaning of pipe shows maximum thinning in bend at 45° from tangent.

FABRICATION of the main steam line for the Salem Harbor Station of the New England Power Company, vital link in more than 52 miles of piping fabricated by Grinnell, is an example of the *many* skills required of Grinnell piping specialists. Grinnell chemists, metallurgists, physicists and radiologists . . . *all* played a part in the bending, welding and testing operations.

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ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL

old cars with new ideas

(*Continued from page 7*)

the Franklin proved itself in these tests, it could not withstand the whispering campaigns and earlier prejudices built up against the air-cooled car. Perhaps the reason may even be psychological. The early part of the twenties was the age of radiator caps. To the Franklin engineers it seemed like heresy to put a radiator cap on for a nonexistent radiator. When they finally succumbed to the demand of salesmen for a radiator cap, the trend turned to concealing the cap. Finally, Franklin turned from cars to making air-cooled engines for aircraft.

We hear today much about how well constructed cars were in the old days. This fact's truthfulness was a function of the individual car and manufacturer. However, some of the equipment used was intriguing. The 1907 Brush used a tree trunk for the front axle. The Brush was also interesting in that it used coil springs for each wheel. The Brush engine also used a counter-clockwise rotation. The Rolls-Royce used a muffler approaching the size of a hot-water heater made of a steel with a gauge guaranteeing lifetime use. The construction on the frame, differential, axle, and driveshaft would put many a bridge to shame. The brakes were mechanical, but it was evident that they wouldn't have the tendency of the Fords to lose a push-rod or two when they became worn. One of the pleasures of old-car enthusiasts is studying the way the early manufacturers tried to solve the problems they were faced with.

Automobile advertising reflects the experimentation and development going on at the time. The individual manufacturer would try to give the purchasing public the impression that he had arrived at the solution and that his product was completely dependable. We find ads such as one for the 1912 Reo, which flatly stated, "The Car That Marks My Limit." Reo says, "Better materials are impossible, better workmanship out of the question." Price is also reflected in the ads. If the car was expensive, the ad would invariably turn to snob appeal. There would be the ever-present chauffeur, with simplicity the keynote. No extravagant claims were made, often nothing was said, leaving it as self-evident that the car was the last word in automobiles. The cheaper cars would display the price prominently, with any other features that may be of interest. A good catch phrase could often be a manufacturer's best asset. We find many famous phrases such as "Watch the Fords roll by" and "Ask the man who owns one" being used. After all, have advertisements changed since then?

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something for nothing

(*Continued from page 10*)

reservoir, such as the ocean, be utilized as work. On the basis of the kinetic theory of gases, the mathematician Maxwell deduced that it was indeed possible to utilize this large source of energy. The temperature of a body, according to this theory, depends on the average kinetic energy of its molecules. The actual energy of the individual particles, however, varies considerably from the average. Maxwell imagined a vessel with two compartments, and in the partition between them there is a small hole with a shutter. There was a little machine, later known as Maxwell's Demon, which opened this shutter every time a fast molecule approached and shut it every time a slow one came near. Thus the temperature of the gas leaking through this hole will be at a higher temperature than before, and the temperature of the remainder is lower. Now some heat engine can be operated between the two compartments, and the loss of heat as work can be made up from some infinite reservoir. This type of machine produces so-called perpetual motion of the second kind to distinguish it from perpetual motion which violates the law of conservation of energy. There have been many attempts at constructing a Maxwell's Demon. All sorts of deflecting plates which would deflect the faster molecules in a different way than the slower ones were tried without success. Similarly, the attempts at producing a potential field which would prevent the slow molecules from reaching one compartment while allowing the more energetic ones to attain it have met with incessant failure. The most famous of these potential field devices was the so-called Centrifugal Refrigerator. Gas was fed into a whirling compartment and the molecules were hurled to the outside by centrifugal force. The gas was extracted from this container both at the rim and at the center. The theory was that those molecules which had very little energy could not overcome the centrifugal force when they rebounded from the walls; so the gas emanating from the center orifice should be at a higher temperature than that coming from the outer one.

Some of the most interesting perpetual motion machines of the second kind do not use a Maxwell's Demon, but use instead radiant energy to bring about the flow of heat from a lower temperature to a higher one. There is one very simple design which consists of portions of confocal ellipses (same foci but different axes) joined by a portion of a sphere with one of the foci as center. An ellipsoid has the property of reflecting all the energy coming from one focus exactly to the other one. A sphere has the property of reflecting all the energy coming from its center back to the center. Thus all the energy coming from both foci ends up at the one at the center of the sphere, and this one should increase in temperature, while the other one should decrease. Despite the fact that these devices were supposed to work, none of them did. Inventors were very puzzled for several years. About 1910, however, some light was shed on the matter. No one has ever shown that perpetual motion of the second kind is impossible, but according to the famous Heisenberg Uncertainty Principle and quantum mechanics, Maxwell's Demon is not possible in principle. The trouble is that in order to measure the velocity of the oncoming particles, the Demon must perform some sort of measurement. But there is no measuring process which can do this without disturbing either the direction, so that they will no longer go through the hole, or the velocity, so that they are no longer going faster than the average. For instance, if light is used, the wavelength of the light must be smaller than the dimensions of the hole in order to tell if the particle is going to hit the hole. But the momentum of the light beam increases with decreasing wavelength. This would be all right if the intensity of the beam could be made arbitrarily small, but even the momentum of a single photon is enough to destroy the accuracy of the measurement of the Demon.

However, don't give up hope just because Maxwell's Demon is not possible in principle. There is another device which proves that perpetual motion is indeed possible. Consider a wheel with a number of spokes extending radially from the center. At the end of each spoke on the ascending side a 6 is mounted. When these 6's get over to the descending side, they are obviously 9's, and are therefore heavier. So the wheel will turn.

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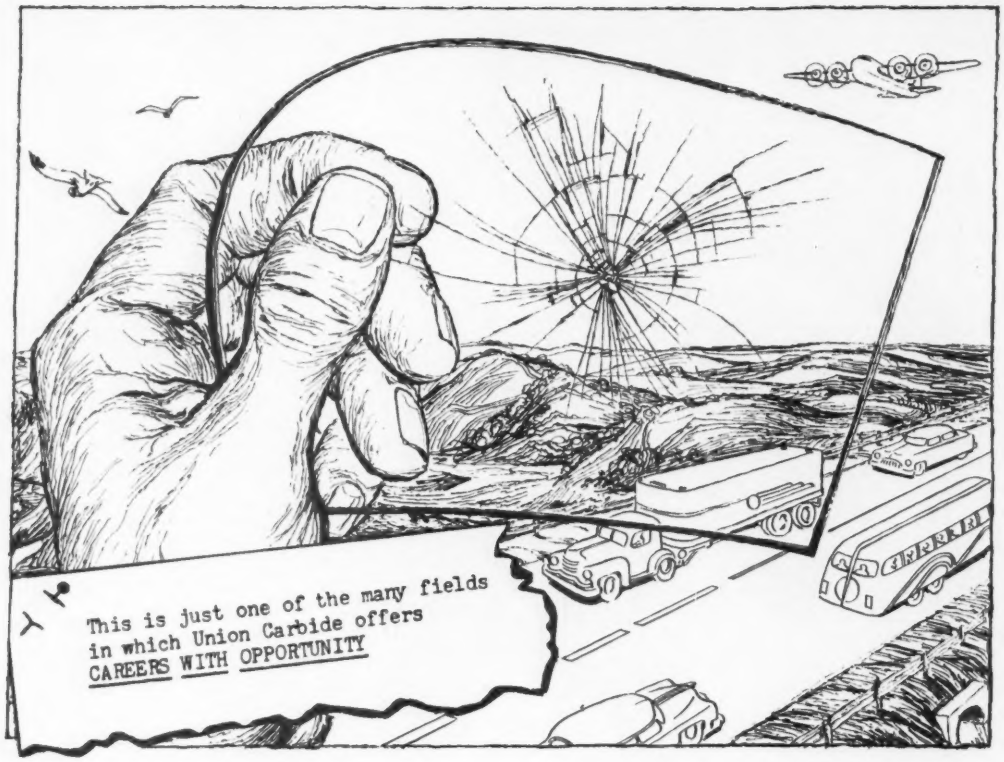

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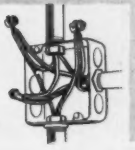

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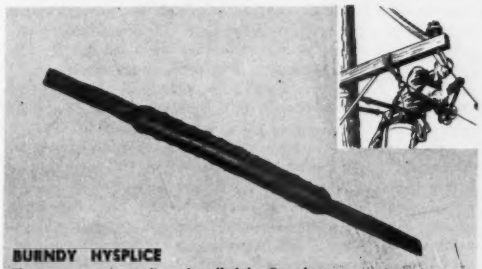

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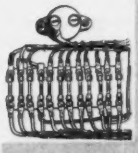

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strength in union (*Continued from page 12*)

should band with his fellows for joint counsel and protection. As a result we now have sixteen million workers in this country in labor unions of one kind or another. And ironically enough, the engineer who traditionally deprecates the existence of labor unions, has been the indirect but prime contributor to their origin and growth.

Although engineers are not ordinarily employed and administered in such large groups as the thousands of production workers in many American factories, there are hundreds of companies now employing several dozen engineers and dozens of companies employing hundreds of engineers. In these, unless they are most unusually managed, the old personal acquaintance and understandings of employer and employee have largely disappeared. Engineers, being no less human than regimented workmen and possibly more sensitive to recognition or its lack, have exactly similar emotional needs in those larger companies and governmental institutions where the chief engineer and his immediate assistants are seldom seen below the top floor. But with the seemingly inborn individualism of engineers, no more attention was apparently needed to humor them than an occasional appeal to their pride of special position by reiterating on suitable occasions that all engineers are a part of management. And so in the main they were happy to maintain the status quo. Perhaps the only ripple which disturbed the smug complacency of the engineering scene was one caused by a few impatient souls who worried about the low prestige of the engineers. They thought it would be enhanced if a single over-all organization could be formed to represent the engineering profession in somewhat the same way the American Medical Association, for example, represents and speaks for the medical profession. This was a fairly academic matter and could be counted on to engage our engineer leaders in debate for a long time.

While the heads of our national engineering societies were still considering the desirability and form of a unity organization which would enhance and protect the interests of all in the profession, the rise of the labor movement, particularly following the passage of the Wagner Act in 1935, produced twin dangers to the unorganized-employee engineers. The first danger appeared with the greatly expanded efforts of the CIO and the AFL to organize the major industrial plants of the country. Engineers, being usually in the minority, were impressed into unions of production workers, this often occurring while the engineers maintained their aloofness from anything smacking of labor unionism. Once in a union, they found great difficulty in getting out. The National Labor Relations Board was reluctant to disturb bargaining groups which had been set up by majority vote of their members.

The clear way to prevent such inclusion of engineers in a production workers' union was to form a defensive engineers organization and become certified by the NLRB as an exclusive engineers bargaining group. This procedure was suggested and recommended at that time by various of the founder societies, and notably the American Society of Civil Engineers. Through this sponsorship a number of employee-engineer organizations were brought into being and certified as labor unions by the NLRB. For example, the National Professional Association of Engineers, Architects and Scientists, one of the large employee-engineer labor unions on the west coast, was formed under these circumstances in 1946.

How have engineers' salaries kept up with the cost of living? In Figure 1 are shown in solid lines two believed-to-be fairly typical salary progression curves for superior engineers employed in any one of several of our larger research, manufacturing or utility companies. Engineer A started work in 1930 at age twenty-two, and was one of those fortunate to be kept on during the depression. At age forty-four in 1952 he is making about $700 per month. Engineer B, who graduated in 1939, is now thirty-five and earning in the order of $625 per month. Not much differential for men nine years apart. Although not entirely, the depression can be blamed for some of it.

But a far more serious concern is indicated by the dotted lines in Figure 1 which start to break away from the salaries-paid lines in about 1940. Our rearmament program began then and brought with it the paired effects of higher income taxes and higher prices. After making computations of estimated income taxes for a family of a wife and two children, and correcting the amount remaining for the increased cost of living, the dotted curves are obtained as the net left for ordinary living purposes. (The effect of the cost of living in the

(*Continued on page 32*)

BEYOND THE HORIZON....

Designers are seeking new alloys from the metallurgist in order to develop higher speed transportation.

Higher speed calls for materials having greater strength in lighter sections, often with little or no sacrifice in toughness. Molybdenum contributes vital properties to better alloys which will certainly be developed for the future.

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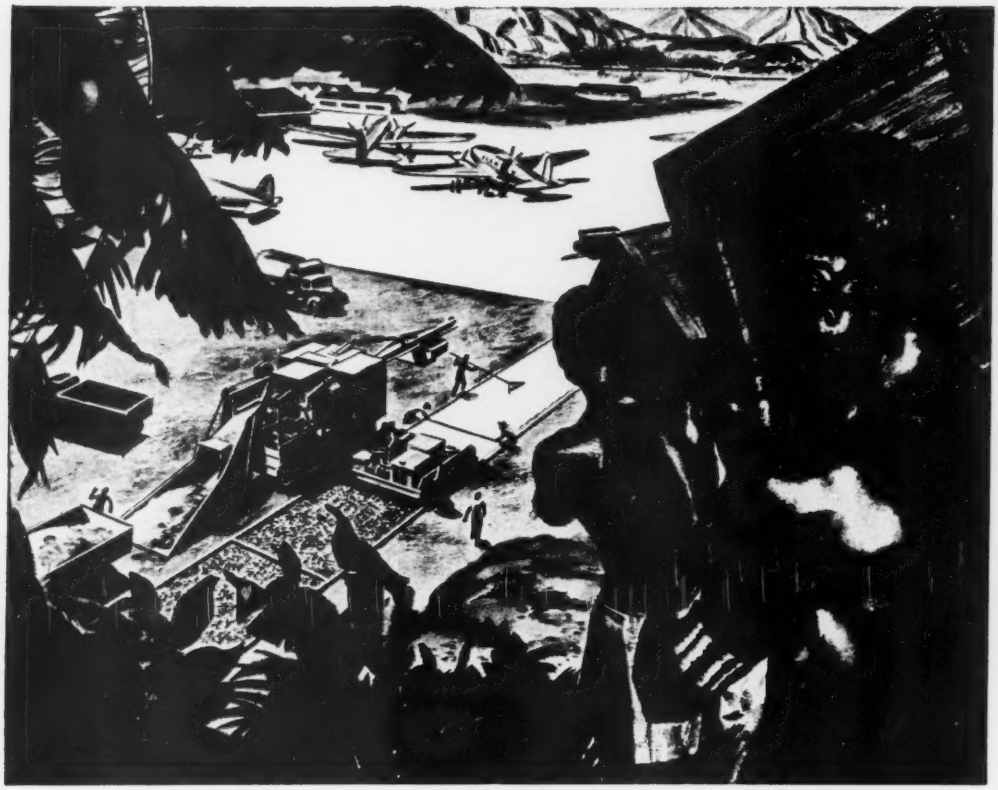

Takes a lot to lay a carpet in the jungle

The scene is "darkest Africa".

But Africa is lightening. Man's quest for minerals, for new areas for agriculture and trade, is slashing ultra-modern, glaring-white air strips in once impenetrable jungle.

Those pavers, portable air compressors, pumps and air tools—such as you might see working a city street—are Worthington Blue Brutes going to "lay a carpet" in that hole in the jungle.

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And illustrates, too, how the unique American talent of *diversification* helps public, employees and stockholders. For Worthington makes many things—not just construction equipment and pumps, but also engines, water works machinery, power transmission, petroleum equipment, air conditioning and refrigeration, many others.

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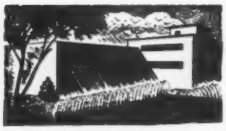

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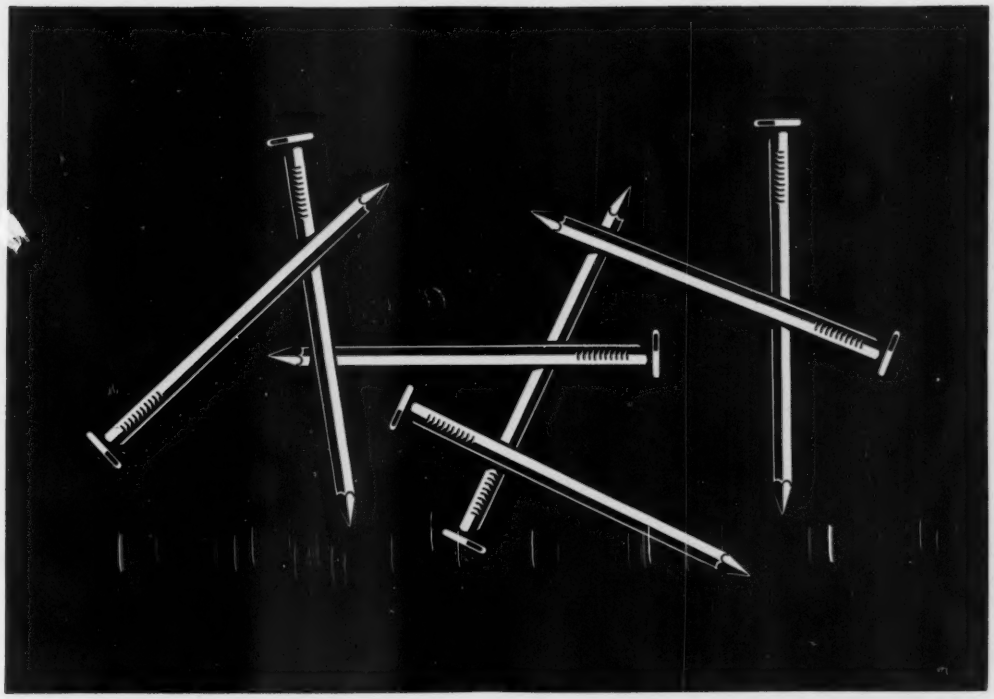

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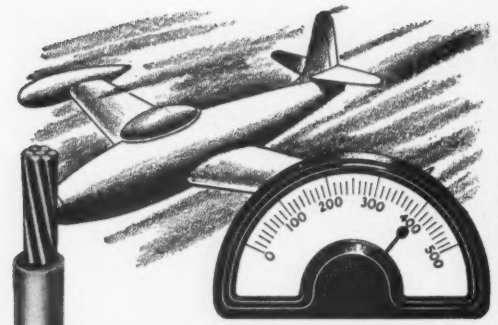

In the development of a new jet engine,

difficulty was encountered due to the intense heats. Since the engine generated temperatures as high as 400°F., even usual heat-resistant insulations on the ignition wires would not stand up.

Okonite researchers were consulted on the problem. Their investigations led them to recommend Okotherm, an insulation of remarkable heat-resisting qualities, made by Okonite. Okotherm retains its dielectric strength over an extremely wide range of temperatures, and was consequently the first electrical cable to gain approval for the new engine.

● ● ●

Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE insulated wires and cables

8788

strength in union

(*Continued from page 28*)

reductions shown is roughly three times that of taxes.) So although it looked as though these engineers were doing all right during this period, getting regular merit raises, their real income progress in the last ten years in fact has been almost negligible.

If one prefers to consider that taxes should not be deducted as a pure loss on the grounds that we have won a war and preserved our freedoms thereby, the effect of the rise in living costs alone is shown in Figure 2 calculated as of late 1951. The curve on this figure is drawn wide to include results from a number of companies since they show a striking similarity in the percentage salary increases received over the twelve-year period, 1939 to 1951, by men of various ages. Although a representative engineer would have been expected to become more experienced and productive during a period of twelve years, and a series of salary increases would have rewarded him accordingly, it is seen from Figure 2 that men in the forty-five- to fifty-two-year age-bracket have actually progressed salary-wise not at all. The younger men who in their earlier years are paid on a more steeply rising progression curve have indeed shown considerable progress, but the men fifty-three and over are really earning less than they did in 1939!

Most engineers think that in any sensibly organized economy where rewards are somewhat commensurate with contributions, the curves of Figure 2 should be totally and well above the cost-of-living line when summary is made over any short span of years. But individually and collectively, engineers, young and old, who have watched these salary trends in the past few years have come to the melancholy conclusion that no matter where one now is on the curve of Figure 2, if things continue as they have and nothing is done about it, the only direction of movement will be down.

So while the first danger to engineering employees (that of being included in production-type labor unions) was being allayed with the much appreciated aid of the national technical societies, the specter of the second danger, loss in real income, arose to take its place. It was entirely natural under these pressing circumstances for engineers who are not accustomed to shy away from difficult and insoluble problems, to meet together in small and large groups and raise the question of equitable salaries and their administration with their employers, the national technical societies and anyone else who would listen.

Now employers are normally in the business of making money for their stockholders, and have pretty universally taken the hardboiled position of yielding on salary matters only when it becomes politically justifiable or economically necessary. Labor unions were in a position to demand and obtain salary and wage increases. Unorganized "captive engineers" were in no position whatever, except a strong moral one, to force consideration of their needs. So they received respectful, but little, attention. The founder societies, while acknowledging economic status to be a proper professional concern, did not choose to give any help. The NSPE, far from taking no hand in the matter, through its Board of Directors issued the statement with which we opened this treatise, strongly condemning engineers' bargaining groups, the only effective means the employee engineers have so far been able to devise for helping themselves.

However, disregarding the open or implied disapproval of the national engineering societies, earnest, conservative, intelligent engineers in dozens of companies have formed associations of great variety, all driven by the normal personal concern to maintain, if not to improve, their standard of living. They proposed to work at this principal problem which their employers and the national technical and professional societies could not, or would not, undertake to solve. The cause of much engineer organization has been as simple as that.

When some compromise solution has been worked out on the salary problem (perhaps the engineer shortage combined with a relaxation of the Salary and Wage Stabilization Board rules on salary increases would have an unexpectedly salutary effect), or these men reach retirement age, or leave engineering for more remunerative fields; no doubt some of these hastily formed engineers organizations will disband. Most of them, however, will have expanded their interests, as we shall suggest in the following, and will find the continuance of their employee associations both useful and rewarding.

There is some question as to the underlying causes which have produced in the last year or two a marked change in the interest which an increasing number of engineering managements are taking in the matter of human relations. It is quite possible that the origin and rapid growth of employee-engineer organizations has occurred in enough of the larger companies to produce concern, if not actual alarm, on the part of their managements (who up to then hardly could have conceived of such audacity) that a general "movement" has appeared to be under way which can no longer safely be ignored. Or alternatively, the unexpected engineer shortage may have caused employers suddenly to appreciate more fully the value of their technical staffs, and that consequently it has become worthwhile to expend good time and money to keep them satisfied and happy.

(*Continued on page 36*)

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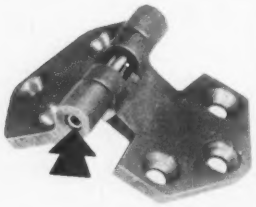
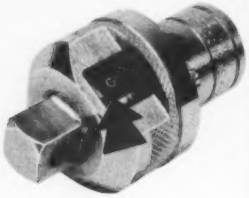
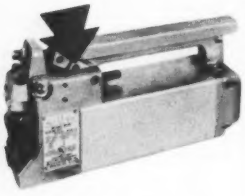


. . . a hinge pin



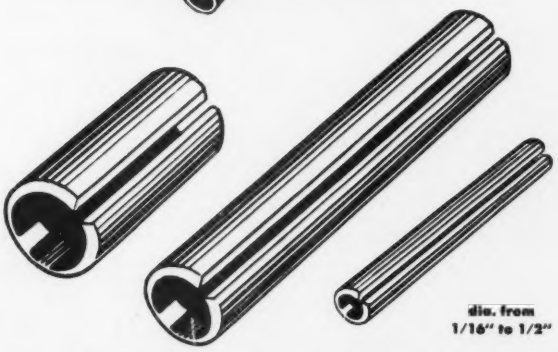
. . . a stop pin

. . . a set screw



. . . a bolt and nut

ROLLPIN TRADEMARK



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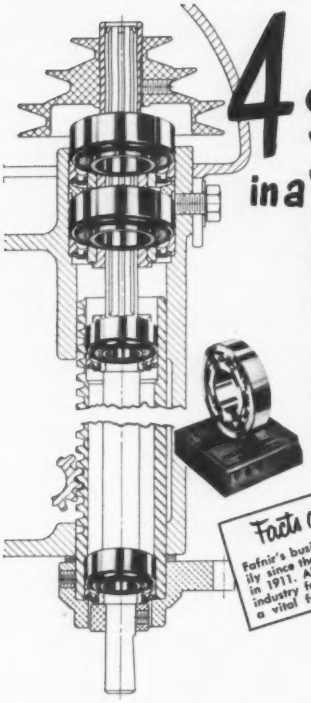

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FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

strength in union

(*Continued from page 32*)

In any event, it is as gratifying as it is astonishing to find engineering executives currently lecturing each other on the vital importance of what Professor Mayo was preaching twenty-five years ago about the recognition of individual human need.

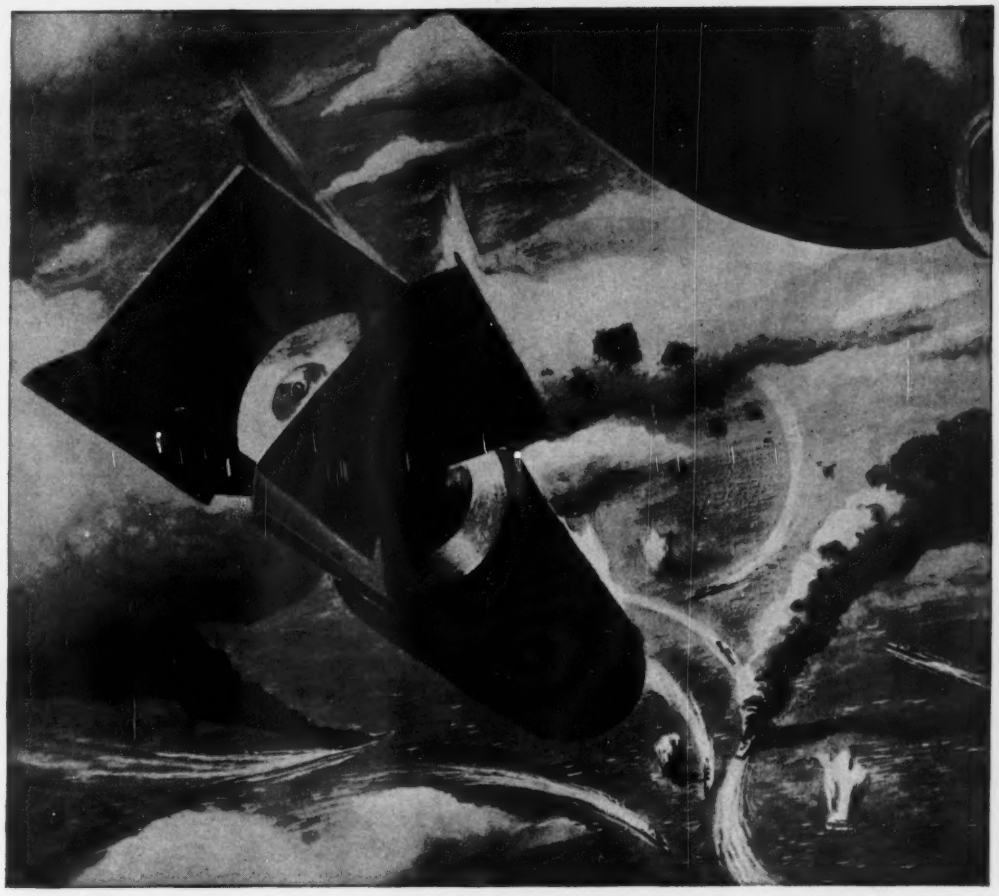
Do the indications we have seen above that the non-technical needs of engineers are going to be given a high priority attention by managements in the future, give us grounds for believing that employee engineer organizations will shortly wither away? Will the need for additional associations to seek the interests of non-supervisory engineers, to express boldly their collective views, and to protect them from predatory production-labor unions be so reduced that the present swelling roll of sounding-board groups and engineers unions will soon level off? Will the engineers regain and maintain at least their standard of living of a dozen years ago in a civilization of material things largely made possible through their ingenuity and efforts?

After careful consideration of the probabilities, one must answer each of these questions in the negative. For one thing, expressions of concern for engineers' welfare have not yet been made by very many companies. And there is the still more difficult problem of translating them from words into actions. Part of the difficulty here, of course, stems from the very natural tendency of managements to resist any invasion of what they have from time immemorial regarded as solely their own prerogatives, put plainly, their right to run the business any way they see fit to make a profit for the stockholders, and no questions asked. More enlightened managements now admit the existence of the public whose wants are to be catered to, and that they need to listen to the views of their employees if they wish to "obtain the enthusiastic cooperation of the men and women who do our work." Too often, however, the harassed management, while nominally holding open the executive door to all employees at any time, are not really "listening."

It is here that the employee-engineer organization (not a Labor union) fulfills one of its most valuable functions, by providing an automatic, continuous and self-starting mechanism for monitoring the actions of management to see that they are neither arbitrary nor governed by expediency, and by being in a position to speak up without fear of individual reprisal. In the positive direction, the engineers' association will assess and screen and pass on to management a thoughtful summary of what the engineers are thinking. This will comprise a minimum program for the engineers' organizations of the future, and it is a worth-while one properly commanding the interest and support of all engineers. Beyond these basic functions, most engineers' organizations will act as professional-service mediums for their members, keeping them informed on matters not likely to be covered in the technical press, urging support of one's technical society, higher professional conduct, and an enlarged participation in community affairs, etc. For these reasons of fulfilling a useful purpose, employee engineers' organizations are here to stay.

Nor is it likely that the salary problem will be solved to anything like the engineers' satisfaction by voluntary action on the employers' part. Publicity, argument, collective bargaining, call it what you will, will continue to be necessary. Associations of the parties most interested are the natural groups for undertaking such activities. They will be around for a long time.

Finally, the employee engineers having seen how to organize among themselves, having found that the dangers in so doing, which reluctant managements pointed out to them, were largely imaginary, and having sensed through some small experience that this is a procedure which gives promise of tangible results, it is highly unlikely that the movement will atrophy. But rather, as engineers are assembled to work in more and larger groups in this country, there will be a corresponding increase in engineer employee organization. The possible regional or national characteristics which they might eventually assume and their relationship with the employing companies is a subject beyond the scope of this article. But there is no doubt that it will depend very largely on the foresightedness and statesmanship of two groups of engineers: those young engineers who will presently fill the positions of engineering management, and those very young engineers who will shortly be accepting the responsibilities of officering the engineers' associations.



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Hughes Fellowship 1952 winners Truman O. Woodruff (left) and Allen I. Ormsbee (right) are welcomed to the campus by Dr. Lee A. DuBridge, President, California Institute of Technology.

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in science and engineering

Semiconductor research is one of the important projects of the Laboratories. A development of immediate value is the Hughes Germanium Diode employed in miniaturized airborne electronic equipment. The apparatus shown in the photograph is a vacuum furnace constructed to produce single crystals of germanium. Discussing its operation are (left to right): Hughes Fellow Allen I. Ormsbee; Dr. H. Q. North, Head of Semiconductor Department; Dr. Allen E. Puckett, Head of Missile Aerodynamics Section; and Hughes Fellow Truman O. Woodruff.

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scientists and the government

(*Continued from page 11*)

budget just what our government spends in support of scientific research. This is mainly owing to the fact that research and development are lumped together as one category. Developmental expenses are always so much greater than research costs, and the boundary line between them is so arbitrary, that one cannot easily separate the two. It is estimated that for 1953, the total federal obligations for research and development will be $2,589 millions, of which $2,038 millions are for the military functions of the Department of Defense. But this does not represent all that is intended primarily for military purposes because, as everyone knows, most of the $265 millions allotted to the Atomic Energy Commission and the $84 millions for the National Advisory Committee for Aeronautics, is directly contributory to military purposes. Thus we see that some 92 per cent of the federal research and development budget is for military matters.

What about the National Science Foundation? This is the new agency on which we pinned our hopes for some federal aid to basic scientific research in our universities, and to assist in training more scientific research workers — without which, by the way, it will be impossible to staff these enormous military development projects. The National Science Foundation was down for some $9.7 millions of estimated obligations in 1953. But I understand that Congress has reduced this paltry sum — about a third of what a civilian agency like the National Bureau of Standards will spend this year on military electronics development — to $4.75 million. This great nation will spend more than $2,300 millions on military research and development, but economy preachments in Congress in an election year will dictate that what our federal budget gives to basic science will be cut from a hoped-for 0.4 per cent to less than 0.2 per cent of the military research budget!

Such a gross neglect of the main-streams of basic knowledge is disastrously foolish, even from the viewpoint of those who believe that future military security of this nation requires the diversion of most of our scientific manpower to military research. One could increase the budget of the National Science Foundation by 1,000 per cent by diminishing the military research and development budget by less than five per cent. Such is the disparity in funds made available by Congress for different areas of scientific work at a time when the Chief of Staff of our armed services can be quoted as saying that, "We know more about war than we do about peace, more about killing than we do about living."

No wonder that scientists find it increasingly difficult to find professional employment that is not related to this all-engulfing effort, and no wonder that the public mind more and more associates science mainly with the development of fantastic new weapons. There is a serious unbalance here which is not good for science nor for scientists nor for the future welfare of our country.

I turn now to another matter in which the relations of scientists to the federal government stand in great need of improvement. I refer to the dishonest political attacks on the loyalty and integrity of scientists and others in the federal service. I call these dishonest for I think that in many cases speeches have been made in which the speaker not only did not have evidence to support his charges, which would be bad enough of itself, but was cynically quite well aware of the fact that he did not have such evidence at the time the speeches were made. How else can we explain the failure of these men to follow up their attacks? Not to do so, if they sincerely believed what they say in such speeches, is as serious a breach of responsible conduct, as are the things of which they falsely accuse others.

In 1947 and 1948 the House Committee on Un-American Activities made great efforts to show that some of the staff of the Radiation Laboratory of the University of California had not properly safeguarded confidential information to which they had access in connection with the atomic bomb project. A great deal of investigating was done both by the FBI and by the Committee's own staff. Unfavorable publicity was given to several of these people, with the result that some of them lost their positions in universities. Yet nothing ever came of this that was worthy of presentation in court.

These things caused a great deal of personal suffering to those involved, suffering and loss of professional opportunity, which still goes on for several of them. One very able cosmic ray physicist has had to turn to potato growing in Colorado; another gifted young theoretical physicist lost his university position but secured another one in Brazil. Another cosmic ray physicist was so hounded that he has left America and emigrated to India.

The damage to science and the federal government's position in science goes far beyond the sufferings of these individuals. Largely as a consequence of this and other incidents, the federal government has set up a vast machinery for investigating all of its employees. I do not question the right of the government to try to assure itself of the trustworthiness of its employees, especially those who are entrusted with confidential information. But I do object to the ridiculous extremes to which this task has been pushed in the hysterical atmosphere of the last few years.

This has resulted in a great deal of needless suffering on the part of obviously decent individuals, has driven many such persons out of federal service, and has caused many others to show a great reluctance to enter federal service under present conditions.

To those who defend these matters by saying that the government must take steps to protect itself against spies, I reply that these procedures have caused a great deal of damage to the federal service, and they have not caught a single spy. I do not know whether there are any to be caught, but I am convinced that the government's so-called loyalty program is not likely to catch one.

These are the main points I want to make. It mainly comes to this: (1) that society has as much responsibility as scientists for any evil use it may make of the results of science; (2) that we are making a disastrous mistake in giving so little support to fundamental research while spending vast sums for military research programs; (3) that the way in which the loyalty investigations in the government are handled is unfair, un-American, and detrimental to the federal service; and (4) that our relations with foreign scientists are being impeded, thus damaging both science and our own prestige as a free country.

It all adds up to a pretty bad picture. But we do not need to be completely downhearted. We as citizens are free to discuss and debate these questions among ourselves, and in this way eventually a better situation will prevail. As long as we retain and exercise our basic responsibilities as free citizens, in spite of the efforts of some of our politicians to coerce and intimidate us into silence, we can have faith that these difficulties, however unpleasant and even dangerous they may be now, will be overcome.

What's Happening at CRUCIBLE

about scoring and cutting rule steel

Lengths of cutting rule steel after edging

Shaped to cut wallet section (note bends, and form-holding method)

Some examples of the many shapes of bends needed

Scoring and cutting rule steel is a cold-rolled specialty steel for use in preparing dies for cutting paper, leather, rubber and other materials.

It is a pre-tempered product manufactured by skilled workmen, using precision rolling and hardening equipment, to close limits for chemistry, grain size and hardness. This product must also be capable of meeting intricate bend requirements in the hardened and tempered condition.

This specialty is furnished with round edges and in coil form to the rule manufacturer who grinds the edges — the one edge square and the other to a knife edge as well as cutting the material into desired lengths. This is sold to a die-maker who bends the rule to the required shape. This is then the nucleus of a pre-hardened die, which when properly brazed and supported is used to cut out material for display cards — aircraft parts — pocketbooks — wallets — gloves — gaskets — washers.

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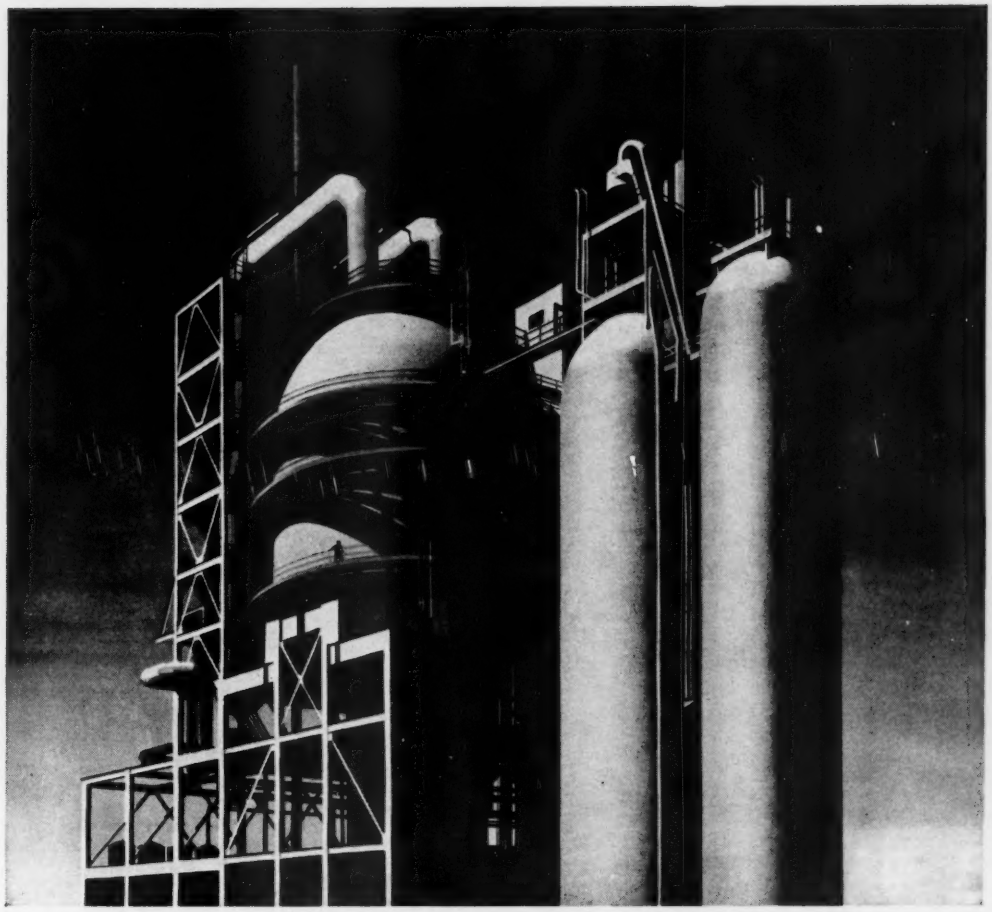

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space, time and einstein

(*Continued from page 15*)

As a result another significant difficulty arises in connection with the hypothesis of absolute time. If the time is measured by a clock in frame K, then the time in frame K', far away from K, cannot be determined instantaneously because of the finite time required to transmit a "signal" from frame K to K'. This difficulty can be avoided by relating distance and time by means of the constancy of the velocity of light c:

$$r = ct$$

Extending this, we may write in general

$$x^2 + y^2 + z^2 - c^2t^2 = 0. \qquad (3)$$

Because of the principle of special relativity, the same situation must prevail in frame K' (c being a universal constant), so that

$$x'^2 + y'^2 + z'^2 - c^2t'^2 = 0. \qquad (3')$$

Equations (3) and (3′) form the basis of the Lorentz transformation, which was discovered many years before Einstein's theory; when applied to the Maxwell-Lorentz equations, it gives correct results. The property that equation (3) must hold in identical *form* when referred to frame K', is called invariance; the study of such invariants is the basic mathematical task of the relativity theory.

Recognizing from the foregoing that distance may be expressed either in terms of spatial coordinates or in terms of time, we can cast equation (3) in a slightly different form by formally introducing a fourth coordinate x_4 according to the scheme

$$\begin{array}{ll} x_1 = x & x_3 = z \\ x_2 = y & x_4 = ict \qquad (i = \sqrt{-1}) \end{array} \qquad (4)$$

so that the length of a vector r in the four-dimensional continuum defined by (4) is given by

$$r^2 = \sum_j x_j^2 \qquad (j \quad 1,2,3,4) \qquad (5)$$

In analogy with equation (3′), the length of the vector r' in frame K' is expressible in the same form as r in equation (5); i.e., the length of a vector is invariant with respect to a transformation of coordinates from K to K'.

Quite apart from its use in relativity, the four-dimensional mathematical formalism brings about very neat symmetry in the electromagnetic field equations, allowing them to be recast in a much simpler and more fundamental form. We see therefore that introducing a time-proportional term in the above manner as a new dimension has basic significance.

In the preceding, the basic postulates of the special theory were illustrated as a logical and experimentally confirmed continuation of classical physics. They are: (a) the laws of physics are the same in all inertial frames (moving with constant translation) of reference; (b) the velocity of light in free space is independent of the motion of its source. The next task is to derive the mathematical relations of the Lorentz transformation based on these postulates, which are embodied in the equations (3) and (3′). By a calculation we find, analogously to equation (2),

$$\begin{array}{ll} x' = a(x - bct) & z' = z \\ y' = y & t' = a(t - bt/c) \end{array} \qquad (6)$$

where u is the constant velocity of K' parallel to K along the X-axis, and $b = u/c$, $a^2 = 1/(1 - b^2)$. The inverse transformation (changing K' into K) is given by changing the sign before u; this is indeed a striking symmetry. The most significant part of this transformation is the factor a. It is unity when $u << c$ but becomes very significant as soon as u starts approaching c. Of course, for very small u, equations (6) reduce to the Galilean transformation.

It is instructive to derive some of the physical consequences of the theory from equations (6). The velocity in K' may be obtained by differentiation:

$$\begin{array}{l} dx' = a(dx - bcdt) \\ dt' = a(dt - bdz/c) \qquad \text{so that} \end{array}$$

$$dx'/dt' = v' = (dx/dt - bc)/(1 - bdx/cdt) = (v - bc)/(1 - vb/c)$$

Upon letting $c = v$, the above expression gives $v' = c$, thus providing a check on our original assumption. Another interesting result is the "shortening" of objects, and the "slowing-down" of time in frame K'. Suppose the length of an object in frame K is $x_2 - x_1$; however, if it is now placed in frame K' equation (6) requires that

$$(x_2' - x_1')/a = x_2 - x_1 \qquad (7)$$

We can measure the length of the object in K' because it is at rest there; if we attempt to measure it in K (relative to which the object is in motion) we will find that its length is shortened by the factor $1/a$. Analogously, the time is slowed down by the same factor. Clearly this means also that the velocity of a material body cannot exceed c, thus giving an additional check on the theory.

The next item in completing the special theory is to bring it in harmony with the classical formulation of mechanics. The two basic laws in question are the conservation of energy and the conservation of momentum. In order to satisfy the latter, Newton's second law is postulated in the form

$$F = \frac{d}{dt}(mv) \qquad (8)$$

which is no longer identical with the classical formula equation (1). In order to retain the law of conservation of momentum, we are forced to conclude that the mass is variable, given by $m = am_0$ where m_0 is a constant called the rest mass. (This result is obtained, for instance, by performing a hypothetical experiment of collision between two rigid bodies and requiring the momentum to be conserved after the collision.) The energy may now be obtained by integrating $F \cdot v$ in equation (8) with respect to time, giving

$$E = m_0c^2a = m_0c^2 + \frac{1}{2}m_0v^2 + \frac{3}{8}m_0\frac{v^4}{c^2} + \ldots. \qquad (9)$$

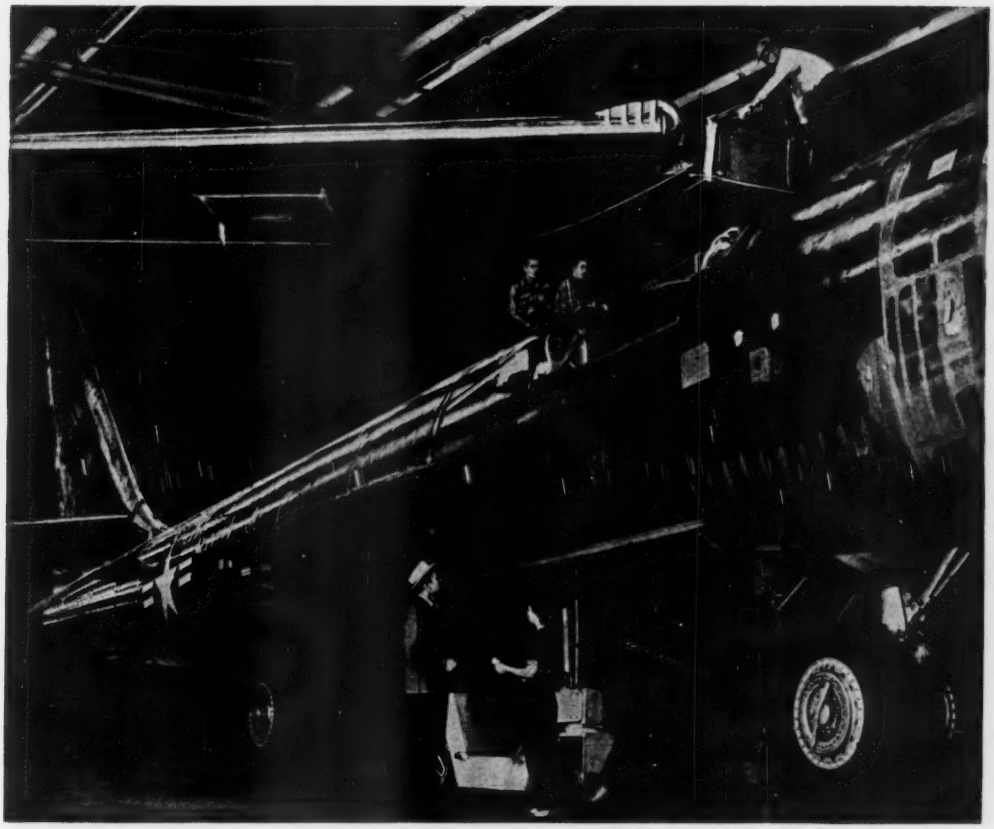
The classical formula for the kinetic energy is represented by the second term; the third and higher terms are neglected when v is much smaller than c; the first term is the so-called rest energy. The variation of the kinetic energy of the body as a function of b^2 is shown in Figure 1. It is evident that the kinetic energy of the body becomes infinite when $v = c$. When the body is at rest, its energy is given by

$$E = m_0c^2 \qquad (10)$$

This leads to the remarkable conclusion that mass and energy are equivalent; to form an idea of the magnitude of E we may calculate it for 1 gram-mass. This gives $E = 9 \times 10^{13}$ joules or 25,000,000 kilowatt-hours!

The foregoing reveals that most of the consequences of the special theory follows in a simple fashion from the properties of the Lorentz transformation. The special theory is therefore neither an abstraction amenable only to a select group of brains, nor an extraordinary intellectual achievement; it is merely a mathematical result of certain (semi-empirical) physical postulates as discussed above. All one has to do to convince himself of these results is to accept the fact that the velocity of light is an absolute invariant constant. It may be

(*Continued on page 48*)



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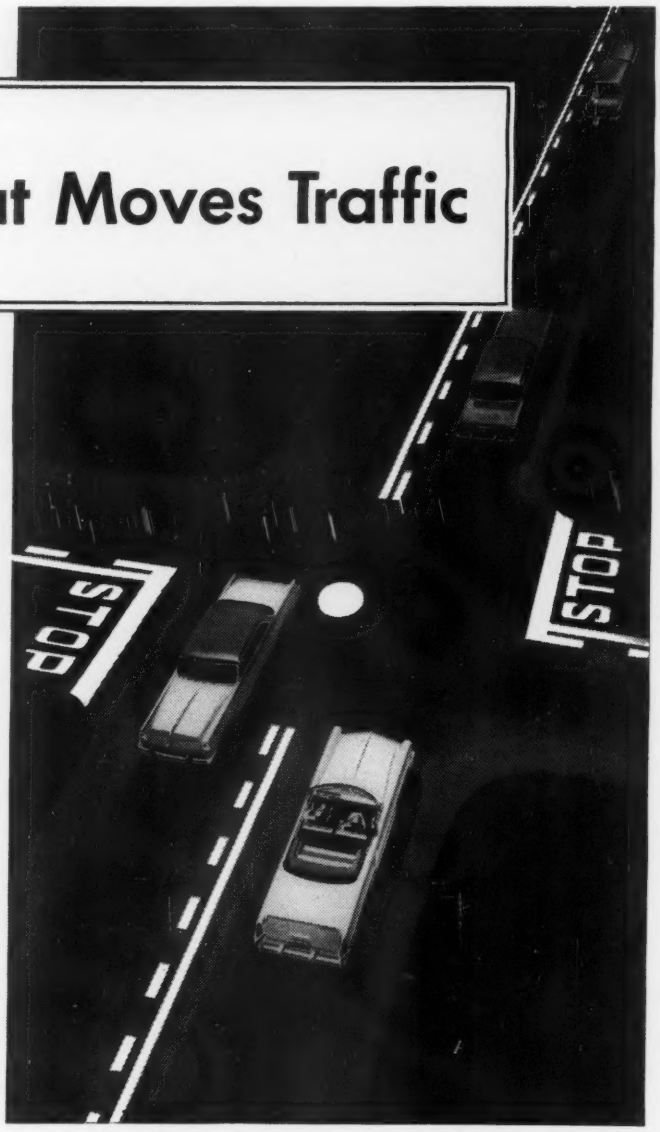

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The Torrington Needle Bearing offers many design and operational advantages. High rated radial load capacity is combined with compact size and light weight. Installation is simple and fast. And one of the major advantages inherent in the Needle Bearing design is the ease with which it can be lubricated.

The full complement of small diameter rollers continuously carries a thin film of lubricant to all contact surfaces. The turned-in lips of the outer shell act as a retainer for lubricant within the bearing and effectively seal out foreign matter. Needle Bearings in many applications run for long periods of time without further attention to original lubrication.

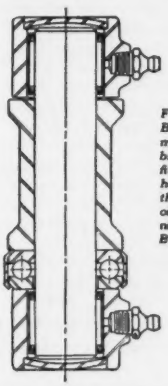

Figure 1. The Needle Bearings in this automobile king pin are lubricated with Alemite fittings through an oil hole in the center of the outer shell. These oil holes can be furnished on all Needle Bearings.

Methods of Relubrication

When Needle Bearings are shipped, they are normally protected with a high-grade slushing compound which has lubricating value at ordinary temperatures. This compound is left in the bearings in most applications.

There are several methods of providing additional lubricant to Needle Bearings:

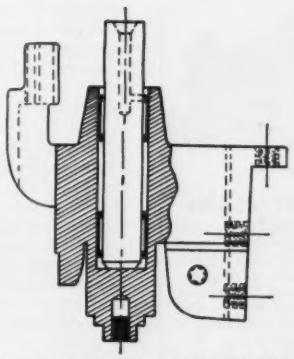

Figure 2. A hole along the axis of the shaft with a cross hole opening under the lip of the upper bearing provides lubrication to the Needle Bearings in this textile machine spindle swing bracket.

1. When lubricant is to be delivered through the housing, as in Figure 1, an oil hole is furnished in the middle of the outer shell. Care should be taken to place this hole outside the load area.

2. If it is necessary to lubricate through the shaft, a hole drilled along the shaft axis with a cross hole leading under the lip of the Needle Bearing is satisfactory. (See Figure 2.) This hole is located under the lip of the bearing rather than in the roller contact area.

3. When speeds are low and loads light, Needle Bearings may be packed with grease, which often lasts for the life of the unit. Such an application is shown in Figure 3.

4. For high speeds and heavy loads, a circulating oil system is preferred, as it aids in carrying away heat as well as in providing a continuous supply of lubricant for the rollers to carry to the bearing contact surfaces. (See Figure 4.)

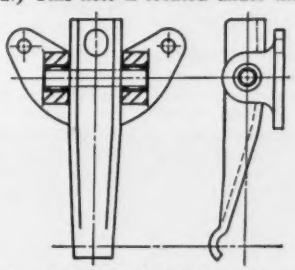

Figure 3. The Needle Bearings in the fingers of an automobile clutch are packed with grease before assembly. No additional lubrication is needed.

Selecting A Lubricant

While oil is the best lubricant, it is difficult in many cases to retain it in the bearing housing. In such cases, grease offers the best means of lubrication. In general, a soda base grease is used in the absence of moisture and a lime base grease when moisture is present. It is usually advisable to consult with a grease manufacturer before making a final decision for a particular application.

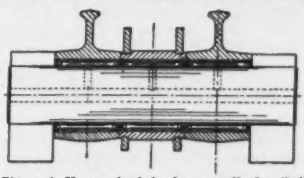

Figure 4. Heavy shock loads are easily handled by the Needle Bearings in this valve rocker arm of a large Diesel engine. Circulating oil lubrication assures a steady supply of lubricant.

If you would like more information on the use of Torrington Needle Bearings, our engineering department will be happy to help you.

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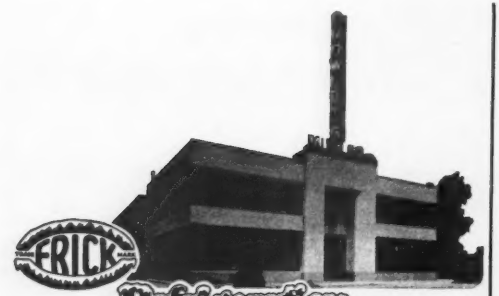

SERVES THIS FINE NEW DAIRY PLANT

Crowley's Milk Company sells a dozen dairy products from its super-modern plant in Newburgh, New York. Here dependable Frick Refrigeration (including compressor, condenser, ice reserve unit, valves, controls, etc.) carries the entire cooling load. When lightning struck last summer, burning out electric starters, the Frick ice reserve unit saved every pound of product.

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space, time and einstein

(*Continued from page 44*)

added parenthetically that the situation is by no means so clear-cut in connection with the general theory of relativity.

The number of instances where material particles (electrons, alpha particles, etc.) are moving with a speed comparable to c is infrequent (electrons inside most vacuum (radio) tubes travel with a much slower speed). Clear-cut examples of this are the various accelerating machines (cyclotron, synchrotron) used in atomic physics. The maximum energies attainable this way are at present roughly half a billion electron volts (500 meV). The rest energy of the electron, from equation (10), is 0.51 meV, that of a proton 935 meV. When the acquired energy of the particle is of the order of its rest energy (i.e., $a = 2$, or $u = 0.85\ c$) we are in a highly relativistic range and the variation of the mass is now an essential factor (it necessitates, for instance, the frequency-modulating of the cyclotron). The rest energy of the proton is so large that we can merely approach it; on the other hand, even at a few million electron volts the electron's velocity is very very close to c, and acceleration (or rather, energy gain) is carried on at practically constant velocity.

The relatively simple physical and mathematical picture of the special theory is largely lost when our attention is turned toward the general theory (1915). The stimulus giving rise to this theory may be found in the remarkable identity known in classical physics long before the special theory:

$$\text{(inert mass) x (acceleration)} = \text{(intensity of the gravitational field) x (gravitational mass)} \qquad (11)$$

In order to assign more than a purely numerical agreement to this result, it is necessary to establish the equivalence between gravitational and inertial mass from a theoretical standpoint. Clearly, this will involve reference frames in accelerated motion with respect to one another. The problem of gravitation appears to have been treated successfully by Einstein's general theory of relativity; on the other hand, attempts to fuse electromagnetic and gravitational effects initiated soon after 1915 have been largely unsuccessful. Although substantial progress was made recently in this direction, the situation concerning this theory is as yet too fluid to be evaluated critically. The aspirations embodied in the general theory are expressed particularly eloquently by Schrödinger:

"In Einstein's theory of gravitation matter and its dynamical interaction are based on the notion of an intrinsic geometric structure of the space-time continuum. The ideal aspiration, the ultimate aim, of the theory is not more and not less than this: A four-dimensional continuum endowed with a certain intrinsic geometric structure, a structure that is subject to certain inherent purely geometrical laws, is to be an adequate model or picture of the 'real world around us in space and time' with all that it contains and including its total behavior, the display of all events going on in it."

Experimental verification of the general theory was obtained in a few instances where such checks were feasible. The theory correctly predicted the displacement towards the red of spectral lines produced on the sun's surface; the bending of light rays in the presence of a very strong gravitational field, the precession of the perihelion of the Mercury. It must be emphasized, however, that only the last of these represents a purely gravitational phenomenon; also, in the above cases, mathematical difficulties make it necessary to solve the new field equations to the first approximation only.

An interesting consequence of the general theory is the fact that the geometrical character of the universe appears to be non-Euclidean. A very crude but instructive picture of this, due to Einstein, is as follows. Imagine a large number of rigid rods as given, all equal to each other. We suppose these laid in series along the circumference and diameter of a circle at rest relative to K'. If C is the number of these rods along the circumference, D the number along the diameter, and if K' is at rest relative to K, we have, in frame K, according to Euclidean geometry

$$C/D = \pi.$$

On the other hand, if K' is rotating with respect to K, the situation is quite different. In this case the rods at the circumference experience a contraction (see Section 3, equation 7) along their lengths, whereas the lengths of rods along the diagonal remain unchanged (although their widths do contract). It follows

$$C/D < \pi.$$

We are therefore forced to conclude that the general theory does not let us use Euclidean geometry. (Of course, this example is wholly nonrigorous, but it does give an idea of the problem at hand.)

Finally, the fundamental difference between the special and general theories of relativity should be re-emphasized: the former follows from well-established postulates and leads to a simple mathematical description; the latter is a very deep-seated endeavor to penetrate into the nature of the universe. The general theory necessitates the use of an elaborate mathematical apparatus. It is a field theory. Its progress has been slow and it will probably not be fully established until more results are available in related fields (better knowledge of atomic physics, solution of mathematical problems, etc.)

There's something here somewhere about laying an egg...

ONCE UPON A TIME there were two farmers. Each had a hen that laid 20 eggs a month.

Both farmers liked eggs, so one ate his. But the other did without, and put his eggs in an incubator which he bought by borrowing money. In no time he had 200 chickens from his one. A shocking profit! (Before taxes.)

He sold some to pay down the loan on his incubator; he ate some as a reward for all his labor in raising the brood. And he sold a good many to pay his income tax.

He still had some left. Profit.

So the farmer who had eaten all his eggs got a law passed. The neighbors divided up the chicken-raising-farmer's "profits" and ate them. After all, they said, he had more than he needed, and they were hungry.

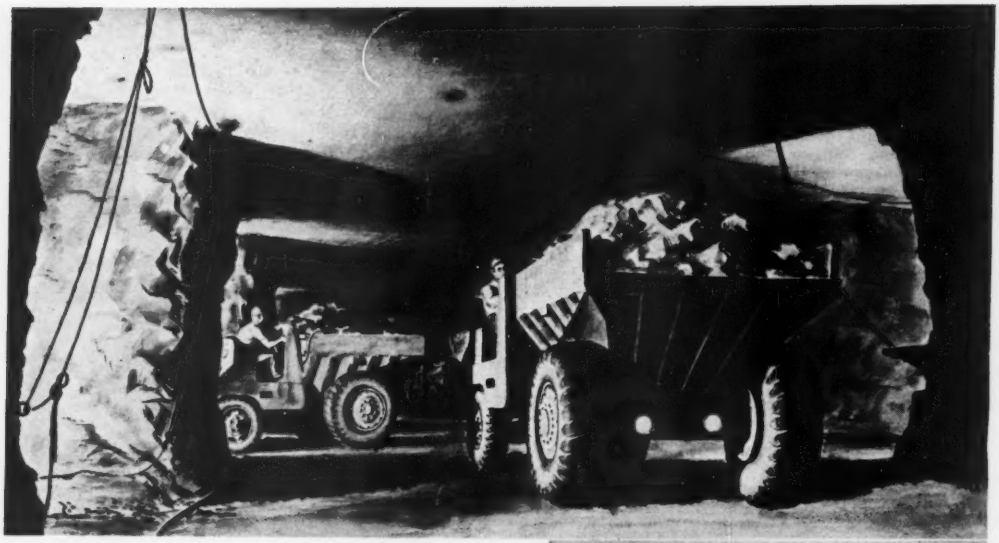
So, of course, the farmer wasn't going to raise any more chickens just to have them taken away from him; he ate his eggs, too.

In due time both the farmers' original hens died of old age, and then there weren't any eggs for anybody. No chickens either.

The neighbors were quite sure it was somehow the chicken raiser's fault.

Did the farmer, who used to eat all his eggs, enjoy his now-eggless meals any more for realizing that the farmer next door wasn't enjoying any chicken?

YOU CAN MACHINE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY TURRET LATHES, AUTOMATICS, AND TAPPING MACHINES



They drive along streets 2200 feet underground

Interesting facts about the world's deepest limestone mine

Big, rugged Diesel-powered trucks roll along corridors as wide as average city streets in the world's deepest limestone mine. This Columbia-Southern project—located almost directly beneath its plant at Barberton, Ohio—assures a steady flow of this basic raw material for the manufacture of alkalies by augmenting supplies from other sources.

This unique operation is but one of many developments pioneered by Columbia-Southern to improve production of alkalies and related chemicals and to serve industry more efficiently from plants located at Corpus Christi, Texas . . . Lake Charles, Louisiana . . . Natrium, West Virginia . . . Barberton, Ohio . . . Bartlett, California.

Massive equipment of modern design—capable of moving 300 tons of stone per hour—was assembled underground. Shovels are 1½ yard, electrically powered.

Limestone is crushed and screened, then brought to the surface by a semi-automatic hoist which attains a speed of 2,000 feet per minute and automatically brakes and dumps at the top.

Workings now include a total of 18 miles of entry and room development. Rooms are 32 feet wide, 17 feet high and are stoped up to 46 feet.

COLUMBIA-SOUTHERN
CHEMICAL CORPORATION
SUBSIDIARY OF PITTSBURGH PLATE GLASS COMPANY

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EXECUTIVE OFFICES: FIFTH AT BELLEFIELD, PITTSBURGH 13, PA. DISTRICT OFFICES: BOSTON • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND DALLAS • HOUSTON • MINNEAPOLIS • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO

THE DU PONT DIGEST

Production for M.E.'s

Du Pont's manufacturing side offers opportunity to mechanical engineers

The young mechanical engineer interested in production finds plenty of opportunity at Du Pont. His skills are in great demand because so many of this Company's products are made in equipment which must operate continuously on automatic controls.

More than half of Du Pont's M.E.'s are currently engaged in some phase of production work. There are three main categories.

1. MAINTENANCE SUPERVISION. Resourcefulness and initiative are needed in men selected for this work. Among their many duties are the scheduling of preventive maintenance and emergency repairs to minimize down time, suggesting equipment improvements to reduce the maintenance load, and estimating costs of changes or major repairs.

Normally, the supervisor establishes maintenance procedures, directs transfer of personnel from one group or area to another, and assigns duties. He sets up office and field work methods and controls the supplies of spare parts and stores.

The importance of this work is emphasized in some Du Pont plants where more men are needed to maintain the equipment than to operate it. At one plant, the division maintenance superintendent, a man with several years experience behind him, is responsible for 1,500 pieces of equipment and 100 miles of pipe. He has 120 men under him, including 10 foremen.

2. PRODUCTION SUPERVISION. Other mechanical engineers at Du Pont use their knowledge of mechanical equipment in solving production problems. They must see that raw materials are on hand, that maximum yields are obtained with minimum loss, and that the products meet rigid specifications. In addition, they must train men in proper equipment operation and maintain good personnel relations.

Production supervisor *T. B. Kelly (at left), B.S. in M.E., Cornell, checks bagging and shipping schedule with operator.*

J. D. McHugh *(at right), B.S. in M.E., Rochester '50, and draftsman discuss working drawings for plant equipment improvement.*

One area supervisor, also an experienced man, usually has charge of from 125 to 150 people, including 6 to 10 foremen.

Keeping compressors *in top running condition is a typical maintenance-group problem.*

3. PLANT TECHNICAL. Other M.E.'s at Du Pont are assigned to the teams of plant technical men responsible for process and production improvements. In this work, they help solve problems on machine design, strength of materials, control instruments, packing materials for high-pressure equipment, etc.

Actually—in maintenance, production and development—the possibilities are almost unlimited at Du Pont for the M.E. who likes the manufacturing side of industry.

HAVE YOU seen "Mechanical Engineers at Du Pont"? 32 pages of facts about opportunities for mechanical engineers. For copy, write: 2521 Nemours Building, Wilmington, Delaware.

DU PONT

150th Anniversary

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Listen to "Cavalcade of America," Tuesday Nights on NBC—See It Every Other Wednesday on NBC TV

The economics of Flexible Shafts
The simple, low-cost way to carry power or control around turns
S.S.WHITE FLEXIBLE SHAFTS

The two products illustrated presented the same problem — how to carry rotary movement around a turn. The designers might have done it with combinations of straight shafts, universals, bevel gears and other mechanical elements. Instead, they saved parts and costs by using S.S.White Flexible Shafts, and they eliminated a lot of unnecessary assembly time and operations in the bargain.

* * * * *

Many of the problems you'll face in industry will deal with the application of power drives and remote control with cost being an essential factor. That's why it will pay you to become familiar with S.S.White Flexible Shafts, because these "Metal Muscles"® offer important savings in transmitting power or control.

SEND FOR THIS FREE FLEXIBLE SHAFT BOOKLET

Bulletin 5008 contains basic flexible shaft facts and shows how to select and apply flexible shafts. Write for a copy.

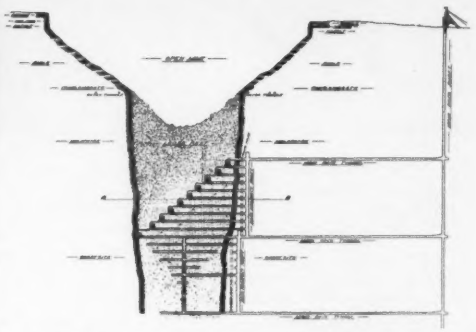
THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO. Dept. C, 10 East 40th St. NEW YORK 16, N. Y.

rich earth

(*Continued from page 17*)

up to this point in the mining and extraction process of the diamonds few if any of them have been visible. It is a rare occurrence for a miner to actually find a diamond in the material he is mining. Some miners who have mined diamonds for twenty years claim never to have seen a diamond.

The final removal of the diamonds from mixture of heavy minerals resulting from the washing is based on the fact that diamonds stick to grease. The heavy mineral mixture is therefore allowed to slide over slightly inclined greased tables that capture all the diamonds and allow almost everything else to slide past. In order to separate all of the diamonds without exception, the mineral mixture is passed over three successive



A section through a Kimberlite pipe shows the shaft and tunnels used to remove the diamond-containing rock.

greased tables. Treating hundreds of tons of blue ground in this manner yields a few diamonds.

The entire world's production of diamonds thus wrested from the earth in one year would fit in a cube two and a half feet on a side. Of this tremendous amount of valuable stones, ninety-five per cent are unsuitable to be cut into the kind of brilliants used in jewelry and are therefore somewhat less valuable. Nevertheless, these diamonds are highly valued for a variety of industrial uses.

Diamonds are used in many cutting and grinding applications, such as machining precision parts, sharpening cutting tools, grinding lenses, and cutting glass. They are also used in the manufacture of electrical wiring to draw the wire to a uniform thickness. Though the diamond is hard enough to do all these jobs, it can be split by tapping it with a hammer. This is due to the internal arrangement of the molecules within the diamond crystal. In addition to all kinds of cutting jobs, diamonds are used in some unusual ways. For example, a few years ago a radioactivity counter was built using a diamond as the radiation detector. This counter proved to be one thousand times more sensitive than the widely used Geiger counter.

In spite of these many useful applications the diamond is still best known for the beautiful jewelry it produces. About one hundred thousand stones suited for jewelry are found each year. While this may appear to be a very large number of diamonds it becomes insignificant when we consider that 125,000 men labor a whole year to obtain this result. Yet it is a result that is undoubtedly worth while.

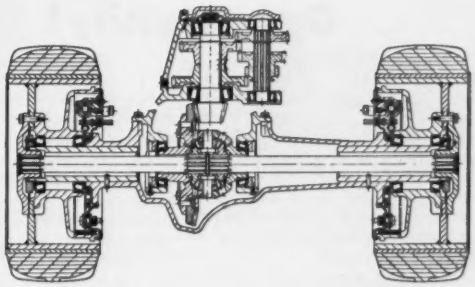
Another page for **YOUR BEARING NOTEBOOK**

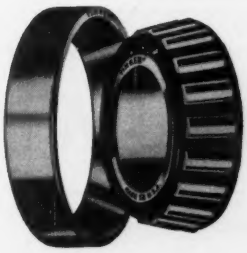
Weight-lifter is no dumbbell— it uses TIMKEN® bearings

When designing a lift truck that would handle like an automobile and lift two-ton loads, Yale and Towne engineers wanted to be sure of smooth, easy operation. That's why they mounted the wheels, pinion, differential and steering pivot on Timken® bearings. They take the high gear loads imposed by sudden starts, stops and changes in direction. Trouble-free operation is insured and maintenance time reduced. Trucks stay on the go.

How to mount a lift truck drive axle and differential on TIMKEN bearings

Two single-row Timken bearings, cone adjusted, are used in the pinion assembly. Cup-adjusted bearings are used in the differential assembly. The wheels use a standard single-row bearing mounting. The bevel pinion adjustment is obtained by the use of shims back of the cup adjacent to the pinion.



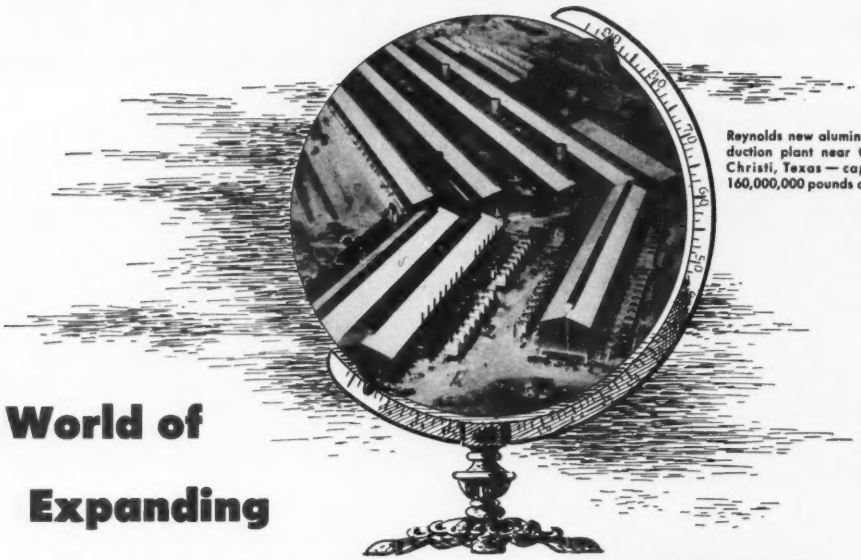


TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

Like to learn more about bearings?

Some of the engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'll be glad to help you. For a copy of the 270-page General Information Manual on Timken Bearings, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◐ AND THRUST —◐— LOADS OR ANY COMBINATION ✳



Reynolds new aluminum reduction plant near Corpus Christi, Texas — capacity 160,000,000 pounds a year.

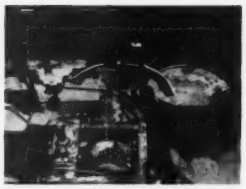
A World of Expanding Opportunity!

In a land noted for rapid expansion of free industrial enterprise, few companies have matched the swift and continuing growth of the Reynolds Metals Company. Now operating 27 plants in 13 states, and still expanding, Reynolds offers the ambitious engineering graduate a world of opportunity.

Reynolds operations include bauxite mining in domestic and foreign locations...chemical and electrolytic processing to produce aluminum pig ...sheet rolling...drawing and extrusion of mill and structural shapes ...foil rolling and printing...powder and paste production...finished parts and products fabrication. In these and in the allied sales and marketing operations promising careers exist for graduates in virtually any phase of engineering.

On-the-job training is the Reynolds policy—after preliminary orientation which may include basic experience in production plants for sales personnel, and sales office work for technical trainees. Liberal insurance, hospitalization and retirement programs are maintained.

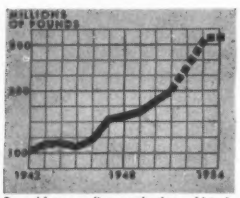
For important background information on "your future in Aluminum," *mail the coupon.* If you are definitely interested now, write direct to General Employment Manager, Reynolds Metals Company, 3rd and Grace Streets, Richmond 19, Va.



Tapping one of huge battery of electrolytic cells

Sheet rolling—reverse hot mill in operation

REYNOLDS ALUMINUM



Reynolds expanding production — historic chapter in 33 years of continuing growth.

Reynolds Metals Company, Employment Dept.
Richmond 19, Virginia

Please send me, **FREE,** your 96-page booklet, "The ABC's of Aluminum"; also the 44-page book, "Reynolds Aluminum . . . and the Company that makes it."

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But Lockheed offers you more than a career. It offers you a new life, in an area where living conditions are beyond compare. Outdoor living prevails the year-'round. Mountains, beaches are an hour from Lockheed.

See your Placement Officer today for the details on Lockheed's Aircraft Training Program for engineers, as well as the better living conditions in Southern California.

If your Placement Officer is out of the illustrated brochures describing living and working conditions at Lockheed, write M. V. Mattson, Employment Manager

Lockheed Aircraft Corporation

Burbank, California

This Plane made History

The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

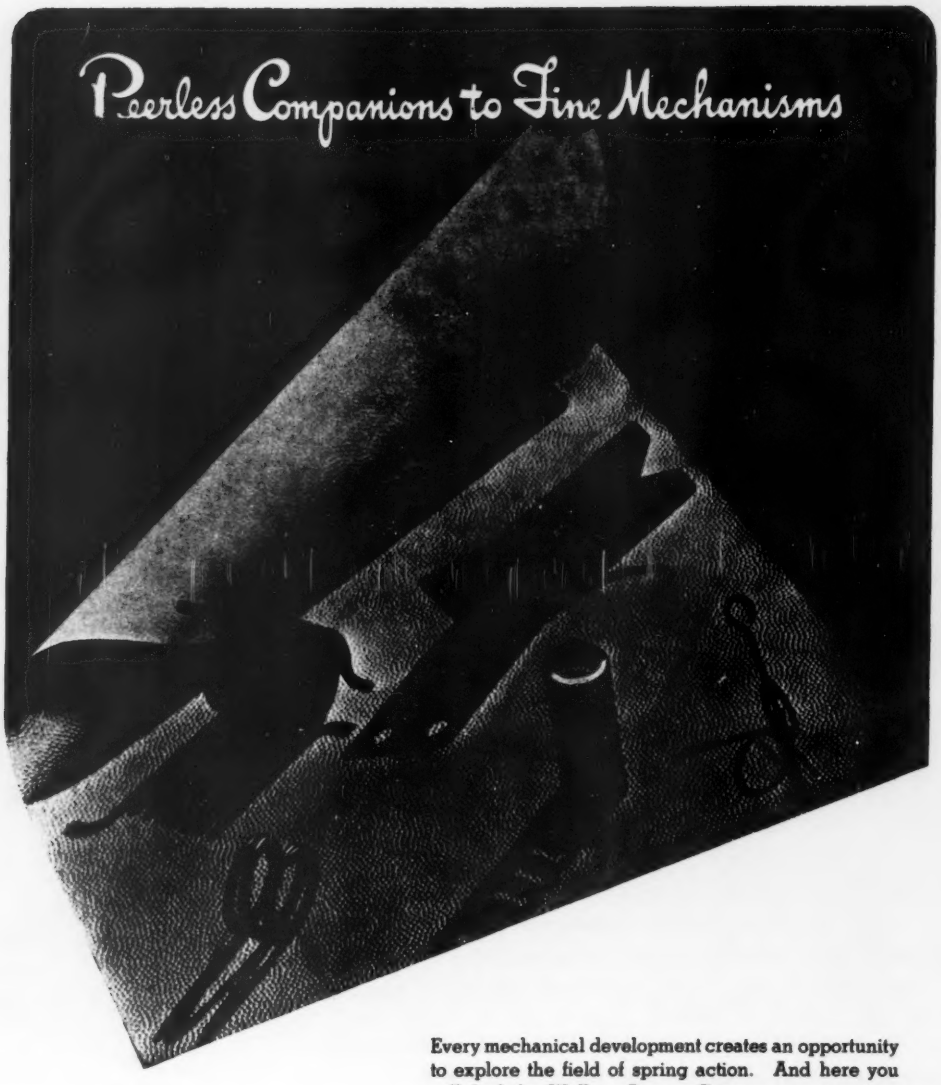
This Plane is making History

The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

This Plane will make History

This plane – which exists only in the brain of an engineer like yourself – is one reason there's a better future for you at Lockheed. For Lockheed will always need engineers with ideas, engineers with imagination, engineers who build the planes that make history.

Peerless Companions to Fine Mechanisms

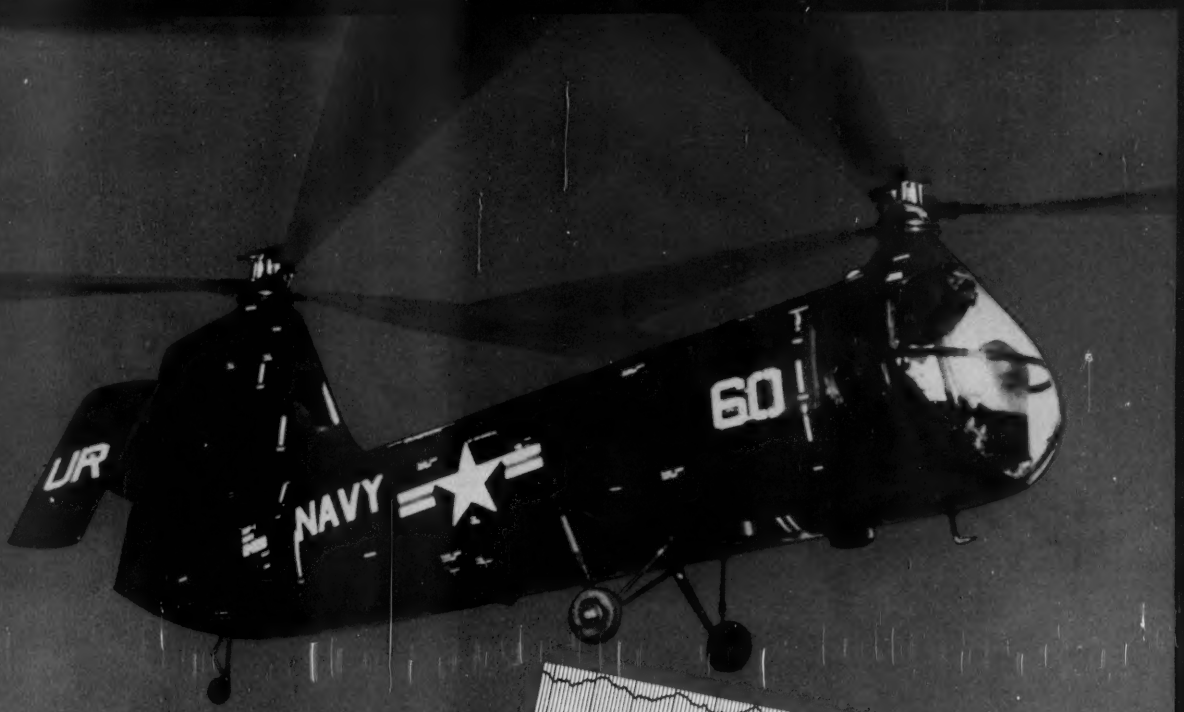


Every mechanical development creates an opportunity to explore the field of spring action. And here you will find the Wallace Barnes Company your partner in mechanical progress. For Wallace Barnes shares its specialized research and knowledge through technical assistance to design engineers in industry.

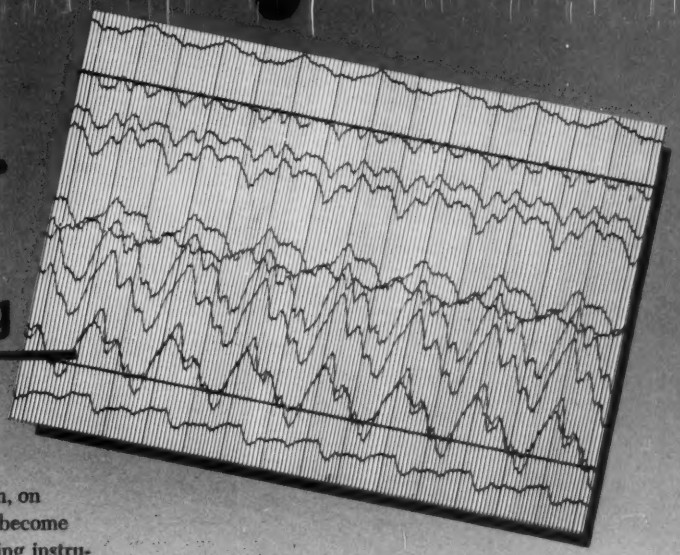
Wallace Barnes Springs

Bristol Connecticut

Springmakers for four generations



Photography... an able helper all through engineering



These traces provide helicopter engineers with information about blade stresses during flight. Strain gages pick up bending at different locations. Photography with its perfect memory catches the whole story as fast as it happens.

In the laboratory, in the drafting room, on the production line, photography has become a most important tool. It records fleeting instrument traces for study. It examines metal structure through electron micrography, x-ray diffraction, and microradiography.

The use of photography in engineering, business, and industry is increasing steadily. This has led graduates in the physical sciences and in engineering to find positions with the Eastman Kodak Company. If you are interested, write to Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, N. Y.

FUNCTIONAL PHOTOGRAPHY
serves industrial, commercial, and scientific progress

Kodak

MY QUESTION TO THE G-E STUDENT INFORMATION PANEL:

"What is General Electric's policy on employment in light of the draft?"

. . . John C. Bennett, University of Rochester, 1953

The answers to John Bennett's question - - excerpts taken from the panel discussion - - are given below.

R. J. CANNING, *Business Training Department* . . . Basically, the Company is interviewing and considering college students for employment without regard to their draft status. We're not passing over men because they are eligible for the draft—we're hiring them if they have the qualifications we want in our employees. We are looking at the area of employment on a long-range basis, and we think we are going to carry a perpetual inventory of men in the armed forces for a considerable period of time. It's true we lose some men, but we get many back, and with this in mind our policy is based on personal qualifications, not on draft eligibility.

J. L. MICHAELSON, *General Engineering Laboratory* . . . We are experiencing a growing appreciation of the importance of an adequate supply of well-trained professional people to this country's immediate and future welfare. Although this situation creates excellent opportunities for you students for future employment, the draft may leave you plagued by uncertainty for the present. But, remember this, we are not only considering college people for employment entirely for the year 1952. We are also thinking ahead to the years '54, '55, and '56, and if we find a good man now, knowing he is going into military service, we will still make long-range employment plans for him. We still would like to have him come with us after he has completed his military service.

M. M. BORING, *Engineering Services Division* . . . Whether or not you are called into military service you can reasonably expect to follow your profession for approximately 30 or 40 years. Your solution to the many problems, such as this one, which arise during your entire productive period, will be a lifetime undertaking. A period spent serving your country in a military way will represent a relatively small part of your total professional life. The way you handle a problem such as this, and the information you get to help in its solution, will determine to a large extent your ability to handle future problems.

Now, where does General Electric stand in regard to this draft situation? This is our policy. Regardless of military status, we desire to interview all students who are interested in our Company. And, irrespective of military status, we will make employment offers to all who have the qualifications we are looking for, and whom we would like to have become members of the General Electric family. If any of these people are called into service before starting work with us, business conditions permitting, our offers will be waiting for them when they return. Those with us before being called into service will maintain continuity, and, barring unforeseen circumstances, will be assured of employment upon return.

Following World War II we did not have to go back on a single promise. When the present world situation is concluded we hope our record will remain the same.

Do you have a question—or seek further information? If so, write to College Editor, Dept. 221-6, General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC